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Physical and Scientific Instruments

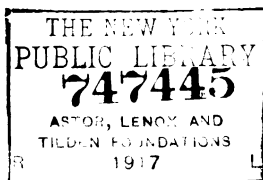
# ELECTRICAL APPARATUS



W. & L. E. Gurley  
Troy, N. Y., U. S. A.

Department P

1908



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**I**N connection with the manufacture of Civil Engineers' and Surveyors' instruments we have equipped a department for the production of Physical and Scientific instruments under the supervision of a competent physicist.

With the most improved mechanical facilities, and the experience of more than sixty years in the manufacture of instruments of precision, we can meet all requirements for accurate and satisfactory work in this line.

We shall be glad to correspond with those interested in Physical or Scientific apparatus. Circulars and other information will be furnished on application.

In addition to our regular list of apparatus, we make to order special instruments and will quote prices on receipt of specifications.

For convenience, address all correspondence in connection with Physical and Scientific instruments to Department P.

W. & L. E. GURLEY,  
Troy, N. Y., U. S. A.

## INFORMATION TO PURCHASERS

**ORDERING** Orders should be written legibly and explicitly, specifying catalogue number. If the charges are to be made to a special board, regular order forms, signed by the proper authorities, should be used. The name and address should be written with particular care.

**WARRANTY** Every instrument is carefully inspected and tested before leaving our factory. Safe delivery is guaranteed, and any damage or defect will be rectified on prompt notification.

**REMITTANCES** Remittances should be made by bank drafts, post-office or express money orders, payable to the order of W. & L. E. GURLEY, TROY, N. Y.

**PACKING** All possible care is exercised in packing, and charges are made for it only when hermetically sealed cases are used for ocean shipments.

**SHIPPING** Unless directed otherwise, we send small orders or delicate instruments by express and large orders or heavy instruments by freight. The cost of transportation must invariably be borne by the purchaser.

# Apparatus for the Measurement of Induction





## INTRODUCTION

**I**N many cases the measurement of inductances is a matter of considerable importance, both in commercial and theoretical work.

The absolute determinations require careful time measurements, and therefore the expeditious and practical method of ascertaining these quantities is by comparison with standards, as is done in the case of resistances.

For detailed discussions and instructions of the methods of absolute measurements, as well as the various methods of comparison, it is well to consult the following :

“Bulletin of the National Bureau of Standards,” Vols. I, II, and III ;

“Absolute Measurements in Electricity and Magnetism” by A. Gray ;

“Handbook for the Electrical Laboratory and Testing Room” by J. A. Fleming ;

“Electrical Measurements” by Carhart and Patterson ;

“Practical Electricity and Magnetism” by J. Henderson ;

“Handbook of Electrical Testing” by H. R. Kempe.

A brief outline of Maxwell’s bridge method for the comparison of inductances, together with diagrams of connections for the comparison of these with other quantities, is given in the following pages. This method is convenient, rapid, and accurate.



### No. 8000 SECOHMMETER

The secohmmeter rapidly reverses the current through the apparatus to be tested and commutes the galvanometer circuit at the same time in order to produce a steady unidirectional deflection.

Two commutators, reversing the battery and the galvanometer connections respectively, are mounted on the same axle, which may be rapidly revolved by a train of gears. An adjustment is provided for, enabling the relative positions of the two sets of brushes to be varied so that any desired lead may be obtained. The crank handle fits either of the two spindles for the production of high or low speeds. A detachable fly wheel is provided. An extra grooved wheel attachable to the spindles is supplied, in case the instrument is to be driven with a belt from some source of power.

Screw holes are provided in the base. All parts are properly insulated.

The instrument is used in the measurement of inductances, coefficients of mutual induction and capacities, or in the inter-comparison of any of these. It is a simple and effective adjunct in the measurement of electrolytic resistances. (For details consult the references given in the introduction and also the outline of methods given on page 12 of this catalogue.)

Price, . . . . . \$55.00

#### No. 8004 SECOHMMETER

This instrument is similar to No. 8000, but is directly connected to a small motor. In ordering, state voltage and whether D. C. or A. C. current is to be used.

Price, . . . . . \$70.00

#### No. 8006 SECOHMMETER

This instrument serves the same purpose as No. 8000, but has the advantage that platinum contacts are used and all possibility of thermal currents is avoided. The gearing is the same as in No. 8000, but instead of the commutator the axle is provided with eccentrics which cause four springs to alternately make and break the battery and the galvanometer circuits. The contacts and the eccentrics are adjustable, so that any desired lead may be obtained.

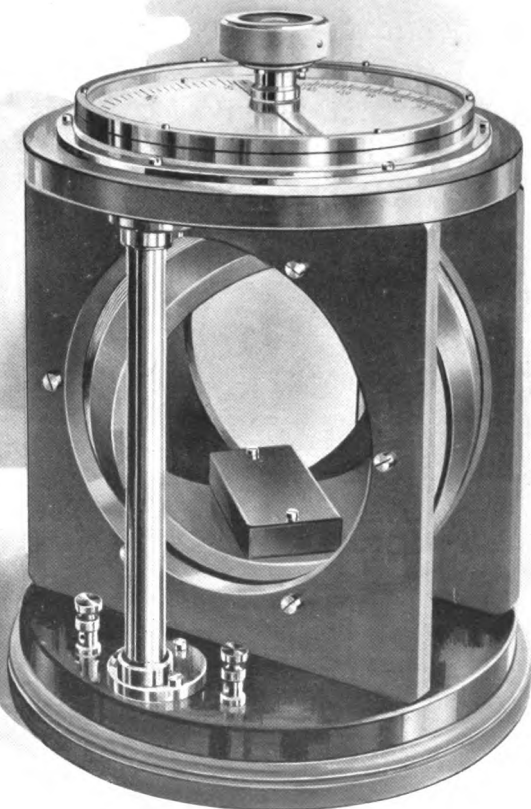
Price, . . . . . \$60.00

#### No. 8008 SECOHMMETER

This instrument is similar to No. 8006, but is directly connected to a small motor. In ordering, state voltage and whether D. C. or A. C. current is to be used.

Price, . . . . . \$80.00

**NOTE.**—A revolution counter and bell can be attached to any of the above secohmmeters, at an additional price of \$8.00.



8011

## VARIABLE STANDARD OF SELF INDUCTION

**No. 8010** This instrument consists of two coils, one revolving inside the other about a vertical axis. The inner coil may be set at any angle with the outer one, and thus the induction varied continuously between a minimum and a maximum value. The coils form parts of concentric spheres, so wound that they lie very close together, and yet allow the inside one to revolve freely. To avoid deformation, the frames are built up of sections of well-seasoned mahogany. All connections are soldered and can be readily inspected. The silvered scale, which is divided into millihenrys through one half of the circle and into degrees through the other half, is protected by a glass cover in a removable brass frame.

The range of the instrument is 3 to 42 millihenrys.

Price, . . . . . \$125.00

## VARIABLE STANDARD OF SELF INDUCTION

**No. 8011** This instrument is similar to No. 8010, but is made of hard rubber instead of mahogany.

Price, . . . . . \$145.00

## VARIABLE STANDARD OF INDUCTION

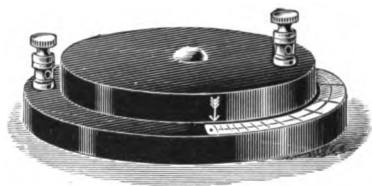
**No. 8014** This instrument is similar to No. 8010, but has the four terminals brought out to binding posts, so that the coils may be used separately for mutual induction experiments, or connected in series or in multiple.

Price, . . . . . \$130.00

## VARIABLE STANDARD OF INDUCTION

**No. 8015** This instrument is similar to No. 8014, but is made of hard rubber instead of mahogany.

Price, . . . . . \$150.00



8020

### **No. 8020** VARIABLE STANDARD OF SELF INDUCTION (FLAT FORM)

This instrument is made of hard rubber. It is direct reading and has a range of from about 5 to 25 millihenrys.

Price, . . . . . \$45.00

### **No. 8025** STANDARD OF SELF INDUCTION OF ONE FIXED VALUE

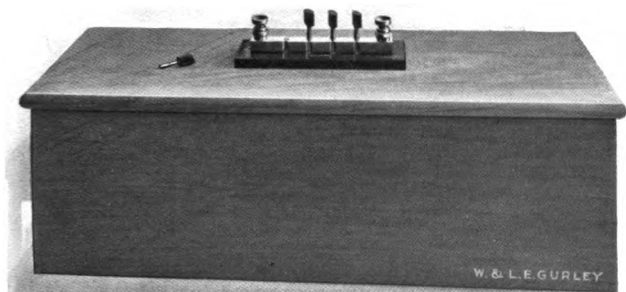
These one-valued standards are wound on well-seasoned built-up wooden spools mounted in mahogany boxes. Any value from 1 to 100 millihenrys can be furnished.

Price, each, . . . . . \$40.00

### **No. 8030** STANDARDS OF MUTUAL INDUC- TION OF ONE FIXED VALUE

These are made by winding a double solenoid on a built-up wooden ring. Any values from  $\frac{1}{10}$  to  $\frac{5}{10}$  can be furnished.

Price, each, . . . . . \$45.00



8031

### **No. 8035 STANDARD OF SELF INDUCTION WITH FOUR FIXED VALUES**

The coils are wound on spools similar to those used in No. 8025, and so arranged in a mahogany box that mutual induction is avoided. The inductances are plugged in and out as in an ordinary series resistance box. The values of the coils are 10, 20, 30, and 40 millihenrys.

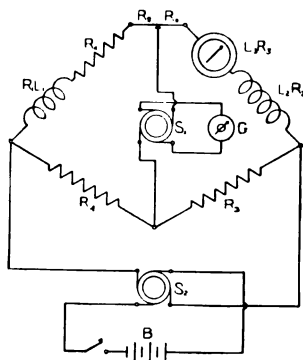
Price, . . . . . \$70.00

### **No. 8036 STANDARDS OF SELF INDUCTION OF FOUR FIXED VALUES**

This box is similar to No. 8030, but is so arranged that when a coil of inductance is cut out of circuit it is replaced by an equivalent non-inductive resistance. The fixed resistance of the box is of great convenience in making measurements, as it avoids rebalancing the bridge.

Price, . . . . . \$90.00

**NOTE.**— If inductances or commutating devices of other values or forms than those listed are desired, prices will be quoted upon receipt of specifications.



## COMPARISON OF INDUCTANCES

To measure the inductance of the coil  $L_1$   $R_1$  connect the apparatus as shown above.  $R_4$  and  $R_5$  are known non-inductive resistances;  $L_2$   $R_2$  is a fixed standard of inductance (No. 8035 or No. 8036);  $L_3$   $R_3$  is a variable standard of inductance (Nos. 8010-8020);  $R_7$   $R_8$  is a wire giving smaller variations of resistance than the smallest coil in  $R_6$ ;  $R_6$  is a non-inductive resistance (see resistance boxes). Having the commutator at rest with the circuits complete through the commutators, making a balance between  $R_4$ ,  $R_5$ ,  $R_1 + R_6 + R_9$ , and  $R_2 + R_3 + R_8$  for zero deflection of the galvanometer as in an ordinary resistance measurement.  $L_2$   $R_2$  is not needed when  $L_1$  is less than the maximum value of  $L_3$ .  $R_6$  is used to produce a balance of resistances and is placed between  $L_1$  and  $R_7$  or  $L_3$  and  $R_7$  according as  $R_1$  is smaller or greater than  $R_2 + R_3$ .



Slowly turn the secohmmeter and vary  $L_2$  and  $L_3$  until there is again no deflection. If no balance can be obtained  $L_1$  is too large or too small compared with  $L_2 + L_3$  and the ratio  $R_4/R_5$  must be changed and the whole operation for the balance of resistances repeated. A change of  $L_3$  entails no change in  $R_3$  and consequently no change in resistance balance. When No. 8035 is used for  $L_2$  each change in  $L_2$  necessitates a rebalance of resistances, but when No. 8036 is used for  $L_2$  the resistance remains constant, however  $L_2$  is changed, and therefore is far more convenient.

When the balance of inductances is obtained as above, rotate the secohmmeter rapidly and make the final adjustment for zero deflection with  $L_3$ , then  $L_1$  is found from the following relation :

$$\frac{L_1}{L_2 + L_3} = \frac{R_4}{R_5}$$

**CAUTIONS** The resistance boxes used should be non-inductive and free from capacity, and therefore the individual resistance arms should not be under 100 ohms and of large wire. (Our high-grade resistance boxes may be used.)

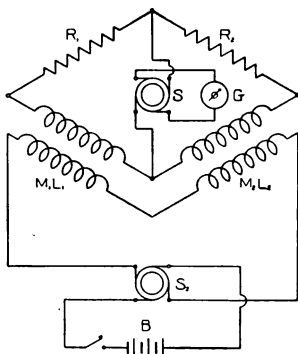
All connections should be as straight as possible.

Foreign magnetic material or strong currents should not be near the apparatus when a test is being made.  $L_1$ ,  $L_2$ ,  $L_3$ , and  $L_4$  should not be too near one another.

All contacts and connections should be good.

As this method depends entirely on the accuracy of the standards, it is well to observe that they are reliable.

## COMPARISON OF TWO COEFFICIENTS OF MUTUAL INDUCTION



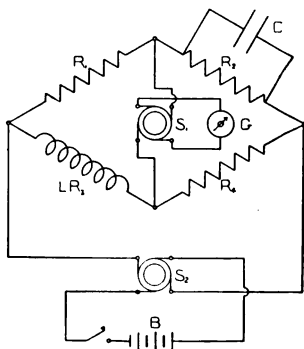
Connecting the apparatus as shown in the diagram and following in general the instructions given on page 12, the following relation holds :

$$\frac{M_1}{M_2} = \frac{R_1}{R_2}$$

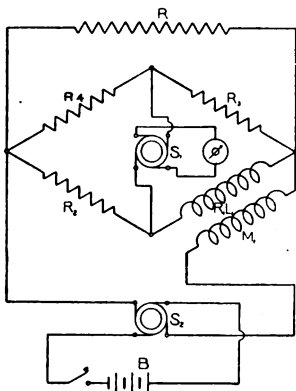
## COMPARISON INDUCTANCE WITH CAPACITY

Connect the apparatus as shown in the diagram and adjust for zero deflection. Then

$$\frac{L}{C} = R_1 R_4$$



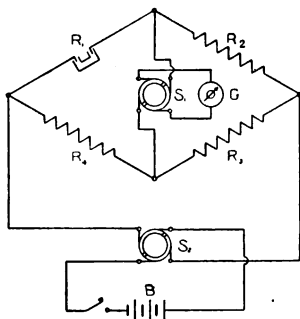
## COMPARISON OF THE MUTUAL INDUCTION OF TWO COILS WITH THE SELF INDUC- TION OF ONE OF THEM



Connect the apparatus as shown in the diagram and adjust for zero deflection. Then

$$L = -M \left( 1 + \frac{R_1}{R_3} + \frac{R_1 + R_2}{R} \right)$$

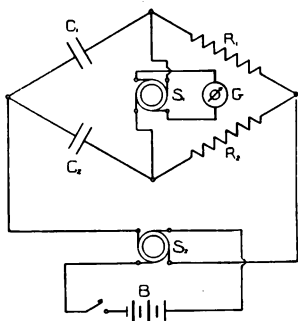
## COMPARISON OF TWO CAPACITIES



Connect the apparatus as shown in the diagram and adjust for zero deflection. Then

$$\frac{C_1}{C_2} = \frac{R_2}{R_1}$$

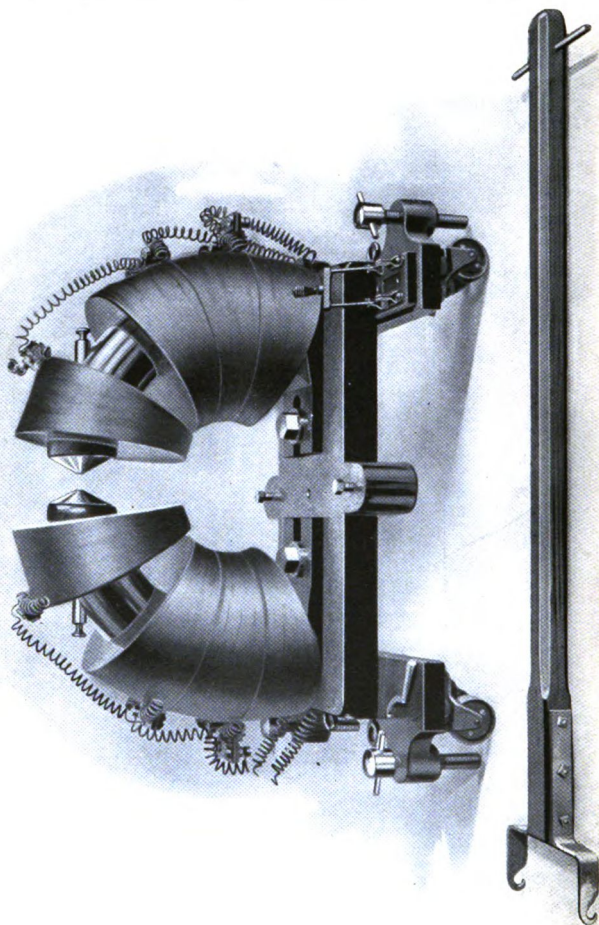
# MEASUREMENT OF ELECTROLYTIC RESISTANCE



Connect the apparatus as shown in the diagram and adjust for zero deflection. Then

$$R_1 = \frac{R_2 R_4}{R_3}$$

# Electro Magnets and Accessories



## SEMI-CIRCULAR ELECTRO MAGNET

**No. 8050** This large electro magnet is a modification of the design by Prof. H. du Bois (*Zeitschrift für Instrumentenkunde*, Vol. XIX, page 357).

The two limbs on the base are made of special soft magnet steel or of Norway iron, as desired. The coils are wound in eight sections and can be readily connected in series or in parallel, or used singly.

The base, which is accurately planed and scraped, is mounted on roller casters and is provided with leveling-screws, which when lowered raise the whole instrument from the rollers. Steel eyes are attached on either end for the insertion of the handle or tongue which is used in moving the magnet. The holes tapped into the top of the base enable the building up of various forms of framework by the use of our standard rods, clamps, etc.—(see our catalogue of *Mechanical Apparatus*).

The magnet limbs have a flange at the bottom and by means of large bolts may be securely fastened at any angle or at any distance apart within the range of the base. The upper end of the limbs have a  $\frac{7}{8}$ -inch hole, which is parallel to the base and may be used for the performance of optical experiments. In order not to have any air gap within the core itself, the pole pieces are threaded with a coarse thread and screw into the limbs. The drilled holes are easily filled by removable soft iron plugs.

The coils are covered with black leather and all the metal parts except the contact surfaces are enameled dark green.

The eight coils connected in series take a current of 25 amperes at about 110 volts, and produce a field of 50,000 c. g. s. lines.

The weight of the magnet complete with switch and connecting wires is about 160 kg.

Price, . . . . . \$455.00

## ACCESSORIES FOR LARGE MAGNET

**No. 8052** Waltenhofer pendulum. This pendulum and its support is readily attached to the base of the magnet. The pendulum disk is made of pure copper. It gives a beautiful illustration of the damping effect of induction, both by instantaneously stopping the vibrating pendulum and by drawing the pendulum into the field when it is displaced to one side.

Price, . . . . . \$20.00

**No. 8053** Laminated copper pendulum for induction experiments.

This pendulum is made of alternate strips of copper and insulating material. It may be suspended from the same support as the Waltenhofer pendulum, No. 8052.

Price, . . . . . \$20.00

**No. 8055** Rotating copper disk. This accessory for demonstrating Foucault or Eddy currents, as well as for showing the warming of the disk when turning in a magnetic field, is readily attached to the base of the magnet.

Price, . . . . . \$20.00

**No. 8056** Attachment for showing the heating effect of Foucault currents. The copper tube for holding the wax, fusible metal or water, may be rapidly revolved between the



poles by means of sprockets and chain, and the heat energy developed may be easily shown.

Price, . . . . . \$25.00

**No. 8057** Attachment to show dia-magnetism and para-magnetism.

This attachment consists of a standard for suspending the different bodies under examination, an adjustable platform on which may be placed the glass chamber, an adjustable spark gap, one light holder, and a case with bodies on which experiments are to be performed. The case contains the following: Iron, nickel, aluminum, bismuth, antimony, tin, zinc, copper, lead, and lead glass, a tube which may be filled with liquids, a shallow dish, and a glass vibrating chamber.

Price, . . . . . \$24.00

**No. 8060** Silver coin and pyramid mirror for the Tyndall experiment, to show the resistance experienced by a conductor when turning in the magnetic field.

Price, . . . . . \$10.00

**No. 8061** Polarization apparatus, with a divided circle fitting the hole in the limbs of the magnet, for showing the rotation of the plane of polarization due to magnetism. Two Nicol prisms having an edge of 12 mm, a quartz plate, a divided circle with vernier, and a parallelepiped of Faraday glass.

Price, . . . . . \$40.00

**No. 8063** Cylindrical pieces of soft steel, turned and threaded at one end to fit the limbs of the magnet. These may be used in making other pole pieces of different form from those furnished.

Price, per pair, . . . . . \$14.00

**No. 8067** Bismuth spiral (Lenard type), for testing the strength of the field, together with calibration curve.

Price, in leather case, . . . . . \$18.00

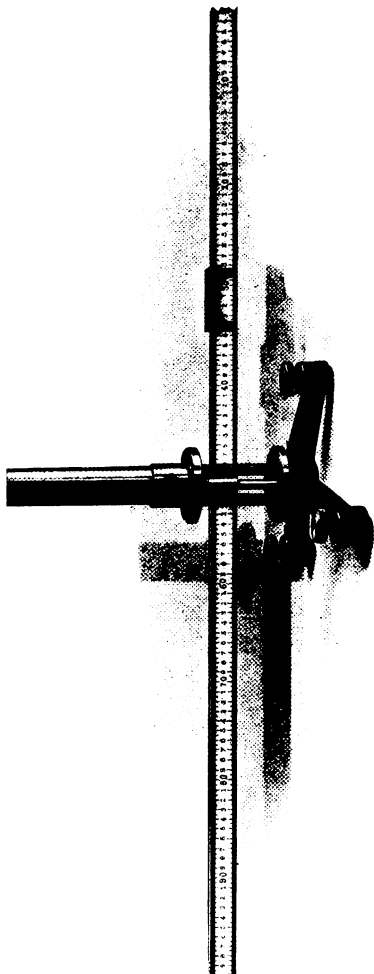
**No. 8070** Small semi-circular electro magnet, similar to No. 8050, but giving a field of 30,000 c. g. s. lines.

Price on application.

The accessories for the small semi-circular magnet can be furnished for the same price as those for the large magnet.

NOTE.—For electro magnets of special design, or of simpler construction, prices will be quoted on application.

# Magnetometers, Inclometers, Variometer, Earth Inductor



8100

## MAGNETOMETERS

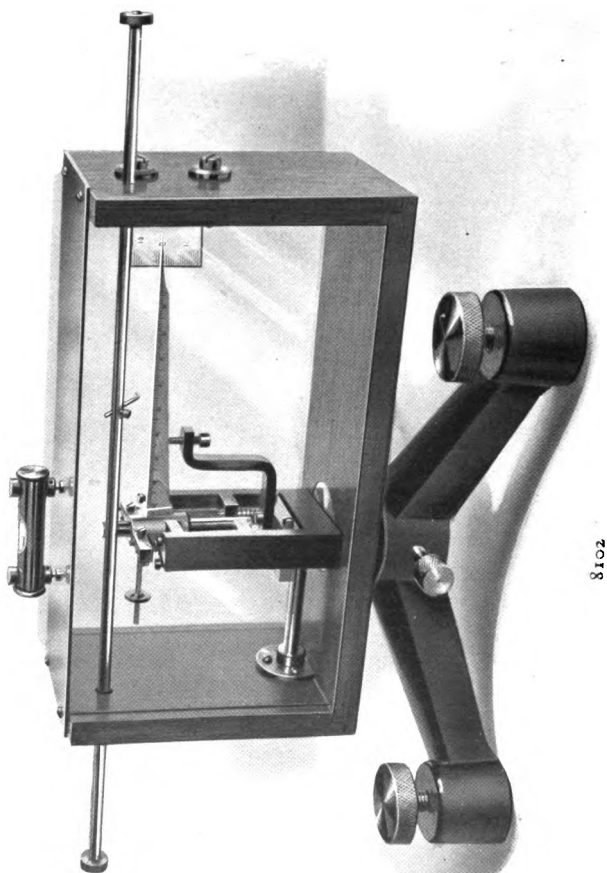
**No. 8100**  $\frac{M}{H}$  Instrument. With the exception of the magnet this instrument is entirely non-magnetic. The bell-shaped magnet is suspended from an adjustable support by means of a silk fibre, and is surrounded by a heavy copper cup which can be raised or lowered. In the former position the eddy currents exert a powerful damping influence on the magnet, enabling the taking of readings quickly and accurately. The chimney with its glass window can be easily removed or revolved on its base. The slide for holding the deflecting magnet is provided with a spring clip and clamp screw.

Price, with deflecting magnet, . . . . \$35.00

**No. 8102** MH Instrument. This is an entirely new form designed for Prof. W. McElfresh. The original idea is taken from the following two articles: "Ueber die bestimmung der magnetischen Horizontalintensitaet mit anwendung der Wage," by Toepler, Wied. Ann., Vol. XXI, p. 158; and "Beobachtungen mit der Magnetischen Wage von Toepler," by Freyberg, Wied. Ann., Vol. XXV, p. 511. In these two articles the details of the theory and series of measurements are given which illustrate the accuracy in determining the magnetic meridian and the horizontal intensity.

The instrument is carefully constructed. The balance system, composed of the magnet and the aluminum frame, is supported by hardened and ground steel points bearing on polished glass planes. An eccentric lifter raises the bearings off the planes when not in use, and insures that the system be lowered into the same place.

To make a measurement, place the magnet in the aluminum frame and carefully move it up or down until the center of



8102

gravity of the system is only slightly below the axis of support. Balance the system by adjusting the knurled nut opposite the divided scale. Set the instrument in the magnetic meridian by slowly turning until the pointer gives a maximum or a minimum deflection, or by lining up the case with an outside compass needle. If the south end of the magnet is above, have the point of the scale directed toward the north, and vice versa. Take the reading on the mirror scale; arrest the system; turn the case and with it the system through 180 degrees, and then move the rider out on the beam until the pointer indicates the same reading as before. If  $L$  is the reading on the beam, namely, the distance of the rider from the axis of the magnet to the point of application of the weight, and  $W$  is the mass of the rider, then

$$MH = \frac{1}{2}WLg.$$

(A small pan and hook are provided, as it may become necessary to hang this on the beam before balancing. Small weights may be placed in this to produce a balance which adds a factor,  $\frac{1}{2}W'L'g$ , to the above equation.)

Price, with magnet, . . . . . \$65.00

**No. 8104** MH instrument, similar to No. 8102, but with a horizontal divided circle and vernier on the base.

Price, . . . . . \$85.00

**No. 8106** Special form of MH instrument, similar to No. 8104, but with mirror telescope and scale attached. Price on application.

**No. 8108** Magnetometer, consisting of No. 8100 and No. 8102. Price, . . . . . \$95.00

**No. 8110** Magnetometer, consisting of No. 8100 and No. 8104. Price, . . . . . \$114.00

**No. 8111** Magnetometer, consisting of No. 8100 and No. 8122. Price, . . . . . \$57.00



8115



**No. 8115** Students' Magnetometer. This instrument is simple in design, strongly built, and well adapted to illustrate quantitatively the methods of magnetometric work.

The  $\frac{M}{H}$  part of the instrument consists of a polished hardwood base holding the needle box. The engine-divided scale is 1,000 millimeters long. The fibre-capped leveling-screws are fitted in brass nuts fastened to the base. The brass needle box may be revolved on its axis. The circular scale is divided in degrees on a mirror to avoid parallax in reading the position of the light aluminum pointer. The crystal-plate cover may be easily removed. The short magnet is provided with an agate jewel. The brass holder for the deflecting magnet slides easily and accurately on the base and its position is noted by an index mark.

The MH part of the instrument consists of a polished mahogany case, provided with leveling-screws, sliding glass sides, and a divided torsion head.

Price, complete, . . . . . \$45.00

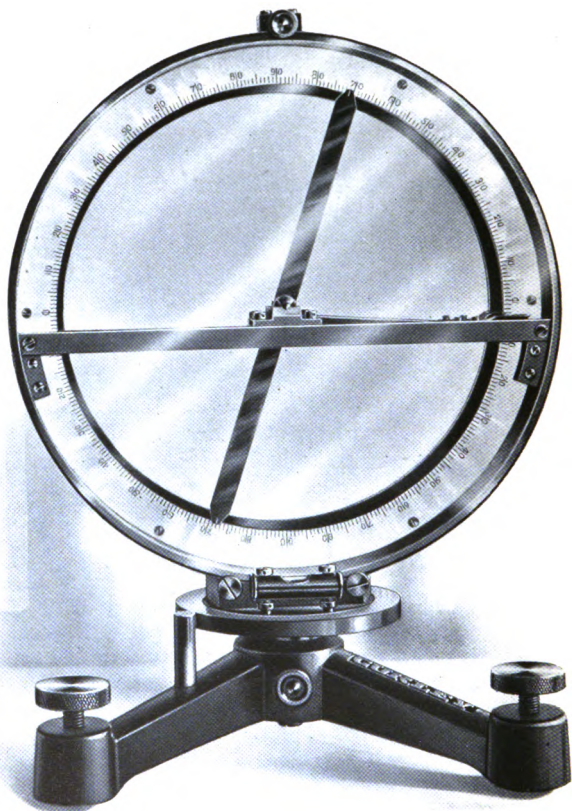
**No. 8117** Students' Magnetometer, similar to No. 8115, but with the short magnet suspended by a silk fibre from a torsion head, instead of being mounted on an agate jewel.

Price, . . . . . \$48.00

**No. 8119**  $\frac{M}{H}$  part of the instrument No. 8115 only. This may be used to determine the relative strength of magnets and, when desired, the vibration part of the experiment may be performed in some case, box, or jar already in the laboratory.

Price, with deflecting magnet and equivalent

• non-magnetic bar, . . . . . \$30.00



8127

**No. 8122** Case for the MH experiment, as described in No. 8115, with magnet holder, magnet, and equivalent bar.

Price, . . . . . \$25.00

## DIP CIRCLE OR INCLINOMETER

**No. 8127** This instrument is intended for college use. The 20-centimeter needle is accurately centered, rolls on agate bearings, and is provided with an arrestment. The silvered horizontal and vertical circles are divided into degrees. The brass case has a ground-glass back and a removable crystal-glass front. The carefully fitted socket is of extra length.

Price, . . . . . \$110.00

**No. 8128** Inclinator, modified Kew pattern. The size of this instrument is the same as No. 8127. The horizontal circle is provided with a slow motion and reads by a vernier to minutes. Two microscopes are attached to the case. Verniers with slow motion screws are provided for the vertical circle, enabling the inclination to be read to 30 seconds.

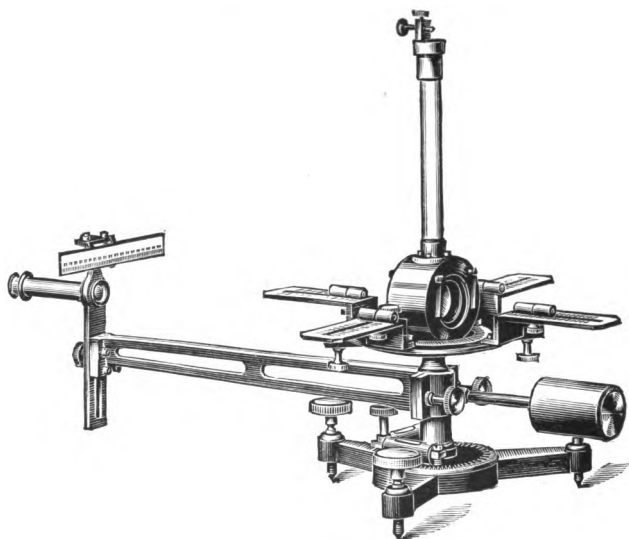
Price, complete in case with extra needle, \$250.00

**No. 8130** Extra needle for either No. 8127 or No. 8128.

Price, with case, . . . . . \$12.00

**No. 8132** Pair of extra needles in case.

Price, . . . . . \$22.00



8136

## INTENSITY VARIOMETER

**No. 8136** This Kohlrausch type of variometer is very compact and can be easily carried. Variations of horizontal magnetic intensity may be determined to  $\frac{1}{100}\%$ . The four deflection magnets act on a polished plane steel mirror, which is not affected by the variation of declination, as it is deflected at right angles to the meridian. A telescope and scale are attached to the instrument.

(For methods of observation see Wiedemann's *Annalen*, Vol. XV, p. 540; D. C. Miller's "Laboratory Physics," p. 366.)

Price, . . . . . \$145.00

## EARTH INDUCTOR

**No. 8140** The laid-up, polished mahogany induction coil is about 24 centimeters in diameter. It revolves about one diameter as an axis, which is at right angles to the axis of revolution of the frame. A divided circle indicates the inclination or the axis of revolution of the coil.

A special spring device releases the coil and throws it  $180^{\circ}$  with a definite speed, or a continuous revolution may be had if desired. The base is provided with levels and leveling-screws.

Price, . . . . . \$80.00

Special forms of magnetometers and magnetometric apparatus, according to our own or furnished designs, made to order.



# Keys for Electrical Testing

## GENERAL CONSIDERATION

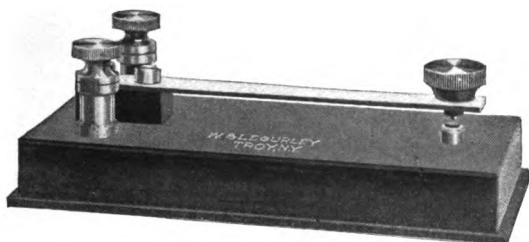
**MATERIAL** The material used in our electrical keys is the best obtainable; the rubber of high insulating properties; the german silver specially hard-rolled to give it proper resilience; the platinum and silver hard drawn.

**WORKMANSHIP** The parts of the keys are made according to standard templets and each part is precisely fitted and carefully aligned. Each post is keyed so that slipping or shifting is impossible. The posts are made plain, but at additional cost may be made corrugated or double walled (petticoated) as designed by Mr. J. Rymer Jones. The latter method gives a longer surface over which any leakage would have to pass and at the same time keeps the larger portion of the surfaces free from exposure to light. All joints and connections are soldered, thus insuring a complete metallic connection with the exception of the movable contact points. All rubber parts are highly polished. In the less expensive grade of keys, the bases are made of polished mahogany instead of rubber. The brass parts are polished and lacquered except at contact surfaces. The german silver parts are grained, figured and lacquered.

**CONVENIENCE** With special regard for the uses to which the keys are to be put, the binding posts and parts to be handled are placed in a position where they are most convenient for the operator.



## SINGLE CONTACT KEY



This key is used in any case where a circuit is to be made or broken. It is very rigid and highly finished.

No.		Price
8200	With platinum contacts, . . . . .	\$5.75
8202	With silver contacts, . . . . .	5.00

## SINGLE CONTACT KEY

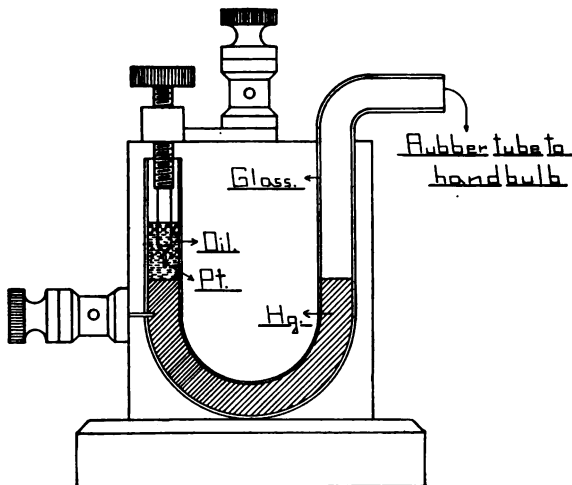


This key is recommended for school laboratories when a number of keys are to be used by elementary students.

It is as carefully made as the high-grade keys, but is not so highly finished. The base is of polished hard wood and the contacts of silver.

No.		Price
8208	With silver contact points, . . . . .	\$1.75

## SINGLE CONTACT MERCURY KEY



This key is intended for use in cases where contact must be made at some distance from the observer and where the movement of the key or the operator's hands would be troublesome. A U tube filled with mercury has a platinum contact under oil at one end and a pressure bulb at the other. By pressing the bulb the mercury is forced up against the platinum contact.

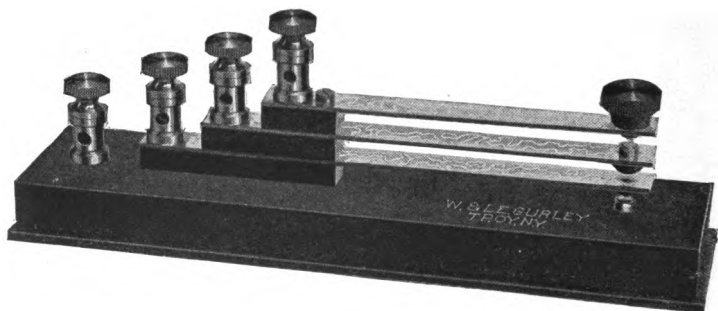
**No. 8212** Complete with bulb but without mercury or tubing. Price, . . . . . \$12.00

## DOUBLE CONTACT MERCURY KEY

**No. 8213** This key is provided with glass valves and is used in cases where thermo-electric effects are to be eliminated.

Price, . . . . . \$15.00

## DOUBLE CONTACT KEY



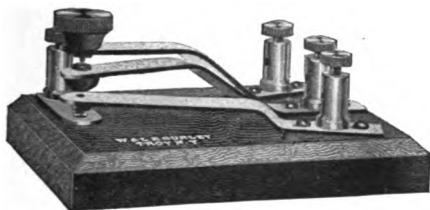
Where two circuits are to be closed a double contact key is essential. The particular form of double contact key shown above is rigidly built and accurately aligned. It is useful in Wheatstone's bridge measurements, as it closes the two circuits in succession.

The upper contact closes the battery circuit and the lower one the galvanometer circuit, the current through the bridge and coils being thus made to assume a steady condition before the galvanometer is connected.

The springs are long, of hard-rolled german silver, and so mounted that all are of the same length, thus giving the key an easy and even touch.

No.		Price
8214	With platinum contacts, . . . . .	\$12.50
8216	With silver contacts, . . . . .	10.00

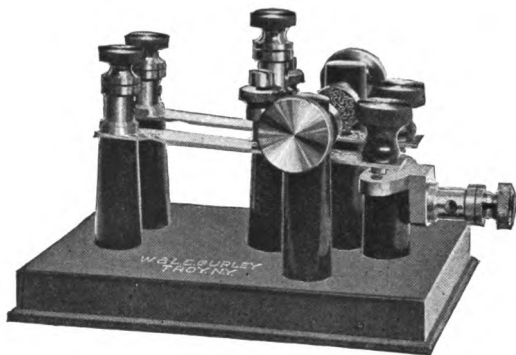
## DOUBLE CONTACT KEY



This key is made in the same careful manner as the high-grade keys, but is not so highly finished. The base is of polished hard wood. It is admirably suited for use in school laboratories where a number are to be used.

No.		Price
8220	With silver contacts, . . . . .	\$3.00

## REVERSING KEY



Besides the short circuit key a reversing key is usually inserted in the galvanometer circuit, in order that deflections may be obtained always in the same direction.

The reversing key illustrated above is recommended for this purpose.

No.		Price
8224	With platinum contacts, . . . . .	\$26.00
8226	With silver contacts, . . . . .	23.00

## PLUG KEYS ON HARD RUBBER BASE

These keys are useful for reversing the battery circuit in tests. Heavy brass segments are firmly screwed on a hard rubber base, and each segment is provided with a binding screw. The plugs are the same as those used in the resistance boxes. Only one kind of plug made to a standard templet is used.

No.		Price
8230	Double-plug key, . . . . .	\$6.25
8232	Single-plug key, . . . . .	4.00

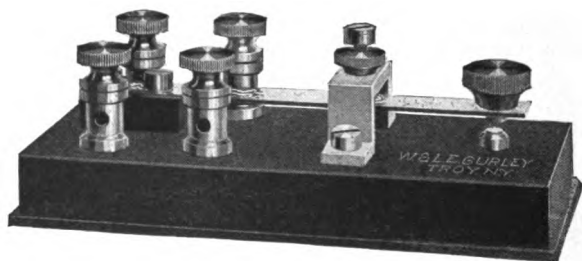
## PLUG KEYS ON HARD RUBBER PILLARS

These keys are similar in use to those above, but are more highly insulated, the segments being mounted on pillars.

The plugs are fitted with a spring ring to prevent the segments from spreading when the plug is inserted.

No.		Price
8236	Double-plug key, . . . . .	\$24.00
8238	Single-plug key, . . . . .	18.00

## SHORT CIRCUIT KEY



This key is intended for use with zero deflection methods. It is connected with the galvanometer in such a manner that when not depressed the galvanometer is short circuited, whereby the induction currents rapidly damp the vibrations.

The spring is made of hard-rolled german silver, and the contacts are accurately fitted. All parts are highly polished, and the key is mounted on a hard rubber base.

No.		Price
8240	With platinum contacts, . . . . .	\$6.50
8242	With silver contacts, . . . . .	5.75

## SHORT CIRCUIT KEY

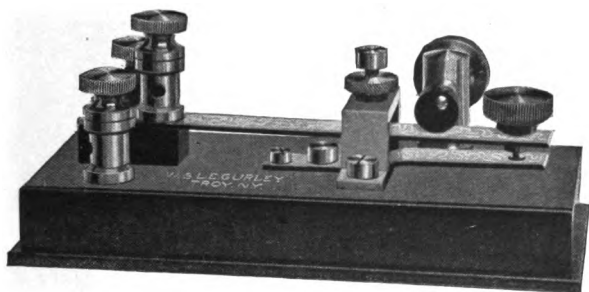
## FOR SCHOOL USE

Similar in form to the preceding, but with mahogany base and silver contacts.

No.		Price
8246	. . . . .	\$2.75



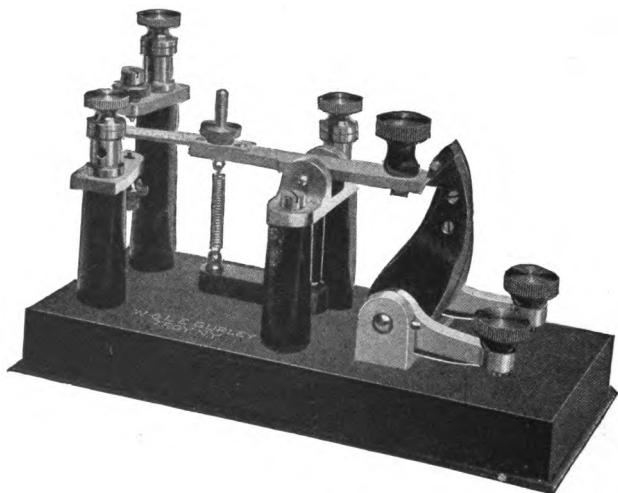
## SHORT CIRCUIT KEY WITH ECCENTRIC



This key is the same as No. 8240, with the addition of an eccentric to keep the battery circuit closed if desired. The construction is such that however much the eccentric wears the contact is not impaired. This is made possible by having the lower contact on a spring instead of a rigid button.

No.		Price
8250	With platinum contacts, . . . . .	\$8.25
8252	With silver contacts, . . . . .	7.50

## KEMPE'S DISCHARGE KEY



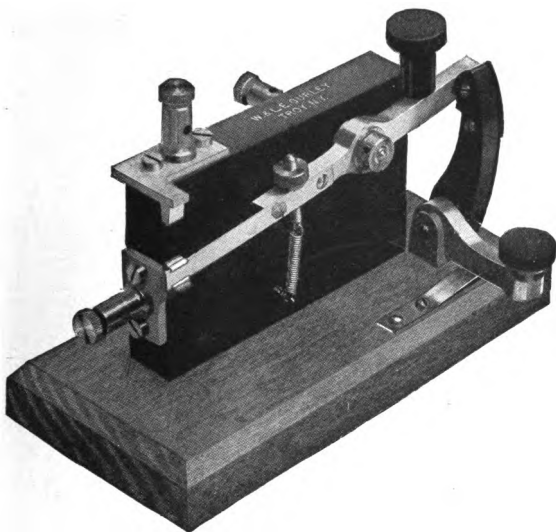
In all condenser work it is necessary to have a charge and discharge key of a form that makes sure and good contacts.

The discharge key, designed by Mr. R. H. Kempe, is very extensively used. It consists of a lever with spring pivoted near the center. The two finger triggers marked "Discharge" and "Insulate" are fastened to two vulcanite hooks. When the finger piece on the lever marked "Charge" is depressed, contact is made with the upper contact, and condenser and battery are connected.

When the trigger "Insulate" is depressed, one of the hooks releases the lever, allowing it to come half-way between the two contact points. When the trigger "Discharge" is depressed, it pulls back both hooks and allows the lever to connect with the lower contact, thus disconnecting battery and condenser and connecting condenser and galvanometer.

No.		Price
8260	With platinum contacts, . . . . .	\$45.00
8262	With silver contacts, . . . . .	40.00

## DISCHARGE KEY



This key is similar in action to the Kempe key, but much simpler in construction. It is designed primarily for school use, and is not so highly finished as No. 8262.

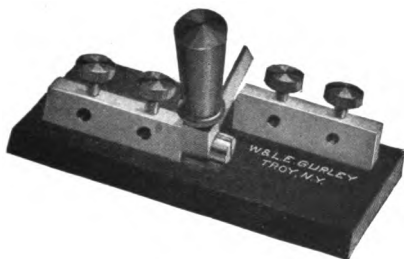
No.		Price
8264	With silver contacts, . . . . .	\$9.00

### LAMBERT'S DISCHARGE KEY

This key possesses the advantage that the principal terminal is highly insulated by the vulcanite bracket and arm when the key is in normal position. In manipulating the key the left-hand lever is depressed, thus connecting the back terminal with the left contact and terminal. The lever is then released and the process repeated with the right-hand lever.

No.		Price
8266	With platinum contacts, . . . . .	\$22.00
8268	With silver contacts, . . . . .	20.00

## DUBOIS-RAYMOND FRICTION KEY



This key is very useful when a battery key is needed, and is extensively used by physiologists. The base and handle are of polished hard rubber. All parts are highly finished and rigidly made. This key is made in two forms, with and without the table clamp.

No.		Price
8272	With table clamp, . . . . .	\$6.50
8274	Without table clamp, . . . . .	5.50

## COMBINATION CABLE TESTING KEY

This key has the functions of battery charging, circuit closing, and short circuit keys. It is very rigidly built.

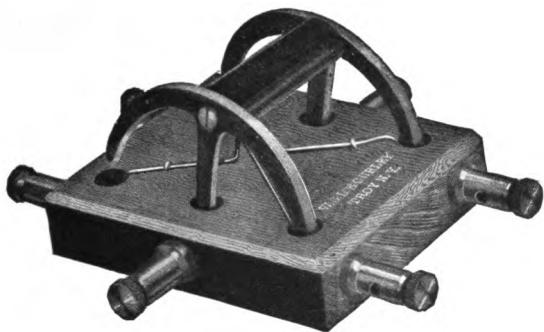
No.		Price
8276	With platinum contacts, . . . . .	\$28.00
8278	With silver contacts, . . . . .	25.00

## CONNECTORS ON HARD RUBBER PILLARS



No.		Price
8280	Double connectors, 6 posts, . . . . .	\$14.00
8282	Double connectors, 4 posts, . . . . .	9.50
8284	Double connectors, 3 posts, . . . . .	7.00
8286	Double connectors, 2 posts, . . . . .	4.40

## POHL'S ROCKING COMMUTATOR



The above illustration shows a simple form of commutator for school use, with polished mahogany base and cast copper rockers.

No.		Price
8290	. . . . .	\$2.50
8291	Similar to 8290, but having a rim around the base, forming a trough to prevent the spilling of mercury, . . . . .	3.50

## MERCURY COMMUTATOR

FOR HEAVY CURRENTS

This form of commutator has copper cups on a hard rubber base.

No.		Price
8294	. . . . .	\$16.00

We are prepared to furnish electrical keys of standard pattern or special design. In the preceding pages are described some of the keys which we make and keep in stock.



# **Tangent Galvanometers**

# **Kelvin Galvanometers**



8300

## TANGENT GALVANOMETERS

**No. 8300** This tangent galvanometer is very carefully made and highly finished. The massive solid brass ring is 34 centimeters in diameter, mounted on a vertical socket, and has one layer of ten No. 18 wires laid in the flat groove.

By means of a plug any number of the turns can be put in circuit.

The needle box can be revolved about a vertical axis, and raised or lowered for accurate centering.

The short magnet is fitted with an agate jewel and has a long fine aluminum pointer. A mirror is laid under the brass circular scale to avoid parallax in reading.

Price, . . . . . \$60.00

**No. 8302** Tangent galvanometer similar to No. 8300, but with horizontal divided circle and vernier.

Price, . . . . . \$75.00

**No. 8305** Tangent galvanometer similar to No. 8300, but with ring split to allow its use as one turn for heavy currents. The magnet is provided with a fibre suspension and mirror, the deflection being read with a telescope and scale.

Price, . . . . . \$60.00

**No. 8306** Tangent galvanometer similar to No. 8305, but with horizontal divided circle and vernier.

Price, . . . . . \$75.00

## UNIVERSAL TANGENT GALVANOMETER

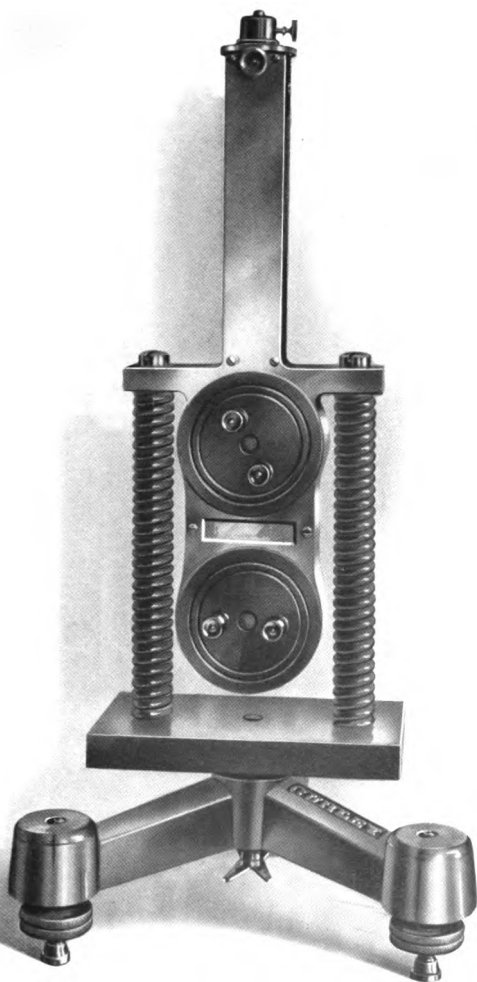
**No. 8308** This instrument may be used as a Tangent, Sine, Cosine, Gaugain, Helmholtz-Gaugain, Wiedemann, or detector galvanometer.

The frame and the rings are of metal. The two rings are 34 centimeters in diameter. One is fixed to the frame, the other can be moved parallel to the former, or may be revolved about a vertical axis, the amount of revolution being indicated on a scale divided to degrees. The rings themselves may be used as conductors, and each is supplied with two sets of windings.

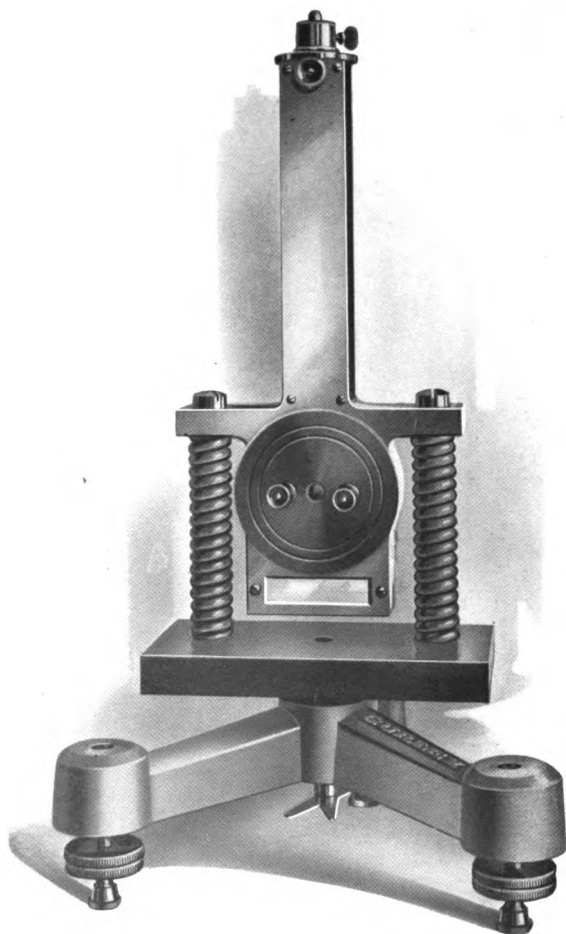
The short magnet is mounted on agate bearing in a brass needle box, which may be revolved on a vertical axis or moved as a whole in a line joining the centers of the circles. A mirror is placed under the aluminum pointer to avoid parallax in reading. The rod upon which the ring and the needle box slide is divided into millimeters, and indices are provided to indicate the position of the two.

For the theory of the various forms in which the instrument may be used consult: Gray's "Absolute Measurements in Electricity and Magnetism"; Carhart and Patterson's "Electrical Measurements"; Kohlrausch's "Physical Measurements"; Winkelmann's "Handbuch der Physik," Vol. IV.

Price, . . . . . \$75.00



8310



8316

## KELVIN GALVANOMETERS

On these, as on all our galvanometers, the front is fastened by means of button-hole joint, so that by loosening a screw the whole front may be removed and the suspension exposed to view or at once taken out. Anyone who has worked with a galvanometer in which the suspension has to be threaded through a tube will readily realize the great advantage of our construction.

The coil frames are supported by long corrugated hard rubber pillars which give an exceedingly high insulation resistance. The coils are  $1\frac{3}{8}$  inches in diameter and  $\frac{1}{2}$  inch thick, and with their frames may be moved in or out, varying the distance from the magnetic system and thus the sensitiveness of the galvanometer. The suspended system weighs only a few milligrams. The suspension is strictly astatic. Controlled magnets are arranged under the base of the instruments. The leveling-screws are fibre-capped.

**No. 8310** Kelvin galvanometer with four coils which can be connected in any combination or series or multiple. Resistance in series 5000 ohms.

Price, . . . . . \$70.00

**No. 8312** Kelvin galvanometer similar to No. 8310 with four coils. Resistance 1000 ohms.

Price, . . . . . \$70.00

**No. 8314** Kelvin galvanometer with four coils. Resistance 100 ohms.

Price, . . . . . \$70.00

**No. 8316** Kelvin galvanometer with two coils. Resistance 2000 ohms,

Price, . . . . . \$60.00

**No. 8318** Kelvin galvanometer, with two coils. Resistance, 500 ohms.

Price, . . . . . \$60.00

**No. 8320** Kelvin galvanometer, with two coils. Resistance, 50 ohms.

Price, . . . . . \$60.00

**No. 8322** Interchangeable pair of coils to fit either of the above Kelvin galvanometers. Resistance per coil, 1,250 ohms,

Price, per pair, . . . . . \$25.00

**No. 8324** Interchangeable pair of coils to fit either of the above Kelvin galvanometers. Resistance per coil, 500 ohms.

Price, per pair, . . . . . \$25.00

**No. 8326** Interchangeable pair of coils to fit either of the above Kelvin galvanometers. Resistance per coil, 250 ohms.

Price, per pair, . . . . . \$25.00

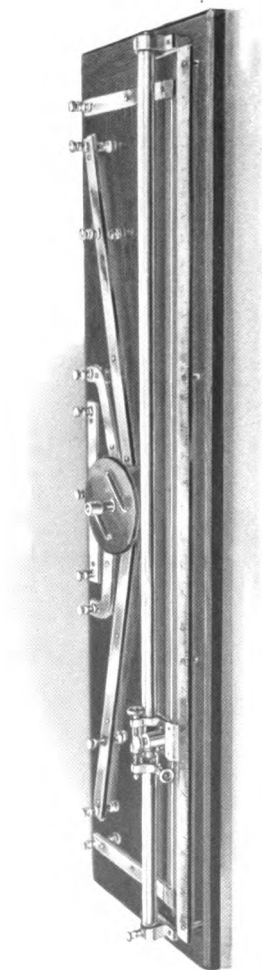
**No. 8328** Interchangeable pair of coils to fit either of the above Kelvin galvanometers. Resistance per coil, 25 ohms.

Price, per pair, . . . . . \$25.00



# Wire Bridges

## Carey-Foster Bridges



8401

## REVERSIBLE METER BRIDGE

**No. 8401** This bridge is designed for the most refined measurements, and for certain purposes this form of bridge is the most convenient and rapid one to use.

The heavy copper bars are raised from the cleated mahogany base by means of hard rubber washers. This prevents any possibility of mercury forming short circuits. The metal parts are bolted through the base, making the instrument unusually strong. Mercury cups and binding posts are provided.

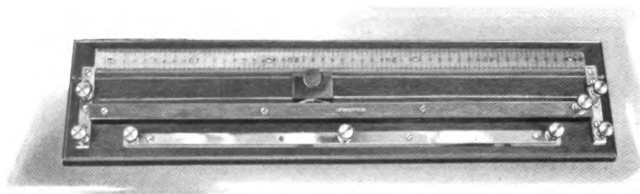
The bridge wire, which is provided with or without constant tension, is of manganin. The slide is of our usual double spring form, provided with coarse or fine adjustment reading with a vernier or an engine-divided metal scale. The feet are provided in order to conveniently stack the bridges in the laboratory.

For methods of measurement one of the following may be consulted: Carhart and Patterson, "Electrical Measurements"; Fleming, "Handbook for the Electrical Laboratory and Testing Room," Vol. I; Henderson, "Practical Electricity and Magnetism"; Price, "Measurement of Electrical Resistance"; Mascart and Joubert, "Electricity and Magnetism," Vol. II.

Price, . . . . . \$60.00

**No. 8403** Similar to above, but with one end bar pivoted and provided with a special spring maintaining the wire under constant tension.

Price, . . . . . \$75.00



8409

## METER BRIDGE

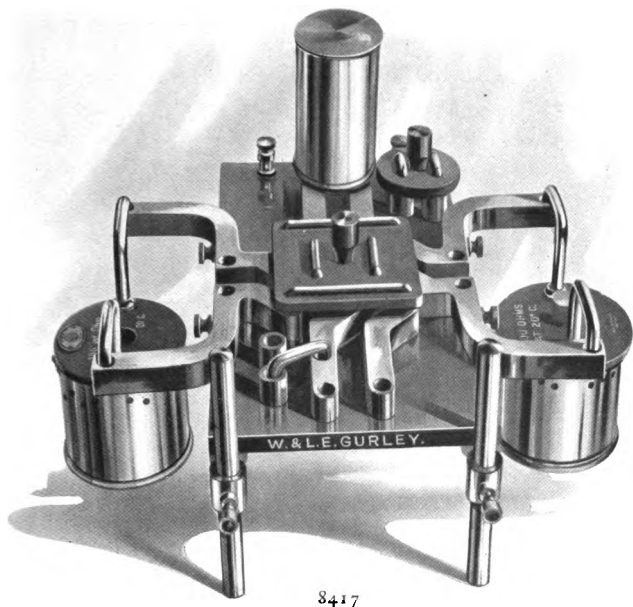
**No. 8407** This meter bridge has a cleated mahogany base, on which are mounted the copper strips, scale and wire. All binding posts are metalically connected. The scale is of box-wood, engine-divided. The slide is constructed principally of hard rubber with our usual double spring contact, which produces a uniform pressure on the wire.

A square metal bar extends the entire length of the base making a good but freely sliding contact, thus avoiding a trailing galvanometer connection.

Price, . . . . . \$15.00

**No. 8409** Similar to No. 8407, but only  $\frac{1}{2}$  meter long.

Price, . . . . . \$12.00



8417

### CAREY-FOSTER BRIDGE IMPROVED FORM

Being provided with accurate resistance standards and resistance boxes, it becomes a matter of the utmost necessity to have equally accurate methods of comparison. When properly constructed, the Carey-Foster bridge has a practically unlimited range. It may be used for the comparison of two nearly equal or two unequal resistances, whether high or low. It gives the simplest and one of the best methods of determining temperature coefficients. The coils in a box may be easily checked and coils readily adjusted by its use. The low resistances of lead

wires and contact resistances are quickly and accurately determined. Percentage errors and the amount of wire to be added or subtracted from a coil to give it a certain value may be found. Directions for any of the above may be found in any of the better known laboratory texts on electrical measurements.

This bridge is formed of two distinct parts, the commutator and the slide wire base.

On the adjustable hard rubber base of the commutator are mounted massive nickel-plated and lacquered copper bars through which the various connections are made. The gaps for the reception of the resistance standards may be varied, the mercury cups are of liberal dimensions, heavy binding posts are attached to the bars, any forms of resistance coils may be tested. The commutator is symmetrical. The coils to be compared may be interchanged without changing the direction of the current through them or through the bridge. The current may also be reversed through the whole Wheatstone net. The Carey-Foster principle is rigorously carried out, which is of utmost importance for accurate work and not true of most forms of so-called Carey-Foster bridges. Four sets of manganin ratio coils (1, 10, 100, and 1,000 ohms) and two manganin low resistance bridge wire shunts are furnished. A U-shaped connector inserted in mercury cups puts these shunts in circuit.

The commutator is connected through mercury to the slide wire by means of heavy flexible copper cables. The exposed parts of the slide are of rubber, avoiding thermal currents or short circuits by the hands of the experimenter. The double spring contact always exerts the same pressure on the slide wire, which is laid on the base beside the engine-divided boxwood scale and not on it. The cleated slide wire base is made with one or more different sized wires.

**No. 8415** Commutator complete with four sets of ratio coils and flexible cables, but without slide wire shunts and without slide wire base. Price, . . . . . \$120.00

**No. 8417** Similar to No. 8415, but with two shunts for slide wires. Price, . . . . . \$130.00

**NOTE.**—Either No. 8415 or No. 8417 can be furnished with the ratio coils mounted permanently on the base and inserted in circuit with plugs, at an additional cost of \$8.00.

**No. 8420** Slide wire base with one wire and contact. Price, . . . . . \$15.00

**No. 8422** Slide wire base with one wire and contact, but having a special spring on the wire to keep it stretched with a constant tension. Price, . . . . . \$20.00

**No. 8424** Slide wire base with three different sized wires and contact. Price, . . . . . \$20.00

**No. 8426** Slide wire base with three different sized wires and contact, but having a special spring on each of the three wires to keep them stretched with a constant tension.

Price, . . . . . \$32.00

**No. 8430** Carey-Foster bridge, combining No. 8415 and No. 8420. Price, . . . . . \$132.00

**No. 8432** Carey-Foster bridge, combining No. 8415 and No. 8422. Price, . . . . . \$138.00

**No. 8436** Carey-Foster bridge, combining No. 8415 and No. 8424. Price, . . . . . \$138.00

**No. 8438** Carey-Foster bridge, combining No. 8417 and No. 8424. Price, . . . . . \$148.00

**No. 8440** Case for commutator No. 8415 or No. 8417. Price, . . . . . \$6.00

**NOTE.**—Unless otherwise ordered, the slide wires will be furnished one meter long.

## STUDENTS' RESISTANCE BOARD

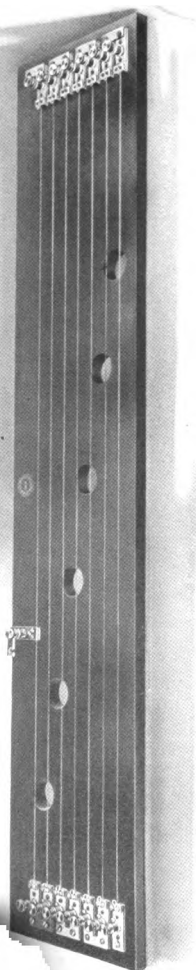
(AFTER PROF. W. L. ROBB)

**No. 8450** Seven wires, each one meter long, are mounted on the cleated mahogany base. The wires are of different materials and of different diameters. One wire is divided to give two lengths. Under each wire a hole is bored to admit the ready insertion of calipers for measuring the diameters of the wires. Binding posts are arranged at either end of each wire. Connectors are furnished, so that the wires may all be connected in series.

8450 Price, . . . . \$25.00

**No. 8451** Resistance board similar to No. 8450, to be used as a students' potentiometer. A meter scale is mounted on the base, and a double spring contact is provided. The seven wires are of manganin.

Price, . . . . \$32.00





# Electrical Resistances

## Resistance Boxes

## Wheatstone Bridges

## INTRODUCTION

THE enormous industrial application of electricity makes the measurement of electrical quantities a matter of great importance. Electrical resistance may be compared with a high degree of precision, the values obtained depending on the accuracy of the standards employed. Much thought and experimentation has been given to these by physicists, particularly those of the Physikalisch-Technische Reichsanstalt, and resistance coils which meet practically all requirements can now be made by the use of proper material and methods.

Our laboratory is supplied with over fifty certified standards, and each coil is checked directly with one of these by the most approved methods. Where a percentage of accuracy of adjustment is stated, it signifies that that accuracy is guaranteed, the actual adjustment being made with a greater degree of precision.

All the resistances are adjusted to the International ohm. Unless otherwise specified, such will be furnished. An extra charge will be made when coils are adjusted to another standard.

## GENERAL CONSIDERATIONS

**T**HE details of exterior and interior construction and arrangement of resistance boxes are practically of as much importance as the accuracy of adjustment, for the convenience and permanency depend upon the structural features.

### EXTERIOR

**METAL CASES** When coils are to be immersed in oil it is best to use brass cases with the sides and bottoms perforated to allow the free circulation of the oil. The finish may be dead black or bright brass or nickel-plated, depending on the use to which they are put and on the taste of the customer. Our metal cases are strong and well made and any desired finish can be furnished. Unless otherwise ordered, metal cases are finished dead black.

**WOODEN CASES** When sets of coils are contained in a wooden box it is made of polished mahogany with the sides dovetailed. All molding from the bottom and sides is omitted, as being an encumbrance in working and storing. Unless specially ordered otherwise, covers are provided to protect the hard rubber and working parts of the tops from dust and light when they are not in use.

**HARD RUBBER TOPS** The hard rubber tops of resistance coils are made of the best grade

of material obtainable, highly polished and covered with a light coat of shellac. The thickness is sufficient to insure a firm support for the brass blocks and coils. When exceptionally high insulation is required, the brass blocks are supported by undercut hard rubber pieces.

**METAL BLOCKS** On plug resistance sets the blocks are of two forms, rectangular and circular, the former being provided on less expensive boxes, and in cases where economy of space is desirable. All blocks are securely fastened by means of screws and steady pins, and are undercut to insure high insulation and at the same time to admit of ready cleaning of the hard rubber between the blocks.

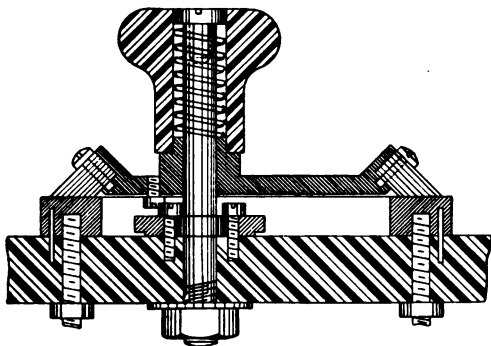
On sliding contact switches the segments are fastened in the same manner as in the plug boxes. As all our plugs and tops are made from standard hardened steel jigs they are interchangeable.

**PLUGS** All plugs are of uniform size and taper. They will neither bind nor become loose, and cannot wear rings or ridges into the sockets of the blocks.

Absolute uniformity is insured by having a hardened steel master plug and socket, and all plugs are fitted to the master sockets and all sockets in the plugs are reamed to precisely fit the master plug. The heads are of two forms, both comfortable and convenient to use. In order to prevent any possible loosening of the heads, they

are screwed, cemented, and pinned to the plug (see figure, page 75).

**SLIDING CONTACTS** Sliding contacts may be very rapidly manipulated and like decade sets the contact resistance remains the same whatever resistance is put in circuit, providing the sliding contacts are properly constructed.



The sectional view shows a very superior construction. The laminated brushes are pressed firmly on the blocks by the constant force exercised by the spiral spring in the handle, thus causing a uniform contact resistance and a perfectly smooth, even "feel."

The edges of the brushes are set at an angle of about  $45^{\circ}$  to the radius of rotation, so that grooves cannot be worn into the blocks. The hard rubber handle with its attached brushes can be readily removed for cleaning. Particular

attention is given to the brushes, which are made of alternately long and short pieces of phosphor bronze. No electrical connection is made through the central shaft, and thus all joints except the bearing joints of the brushes are soldered or brazed. The brush holder is provided with a clip which engages into an indented ring in such a manner that the brushes always stop on the center of the blocks, and the operator knows the position of the brushes from the touch.

**BINDING POSTS** All binding posts are of standard size, pinned and soldered to the blocks and bolted or pinned to the rubber tops, and cannot come loose.

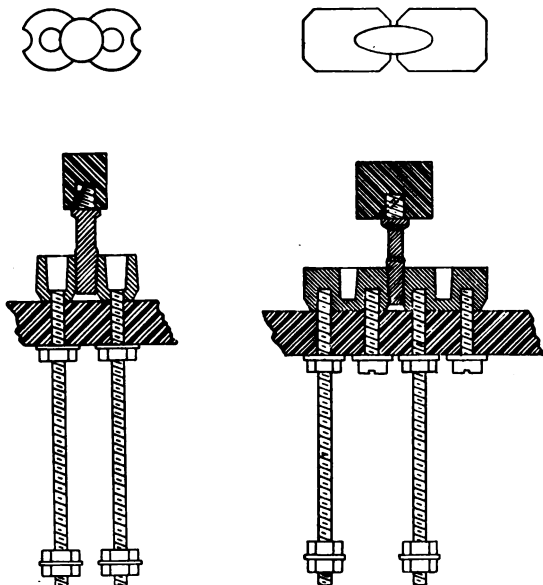
**ENGRAVING** All figures, letters and markings used on the resistance boxes are engraved and not stamped. This is an important consideration, as the former method cuts away the material without bruising, while the latter method produces unsightly results, particularly on rubber.

## INTERIOR

As much care has been taken with the interior of the resistance boxes as with the exterior, and inspection and testing of the coils is always invited.

**SPOOLS** The spools are made of the following forms :

1. Thin metal cylinder of the form recommended by the Physikalisch-Technische Reichs-



anstalt. These give a large radiating surface and free access to air or oil.

2. Metal cylinder about 1.5 cm. in diameter and 10 cm. long, similar to the above, but made smaller to economize space.

3. Composition spools of hard rubber and cement, which are far superior to wooden spools, on account of their insulating properties and because they do not absorb moisture as do wooden spools even when shellaced.

4. Wooden spools for resistance coils are made for special instruments when desired.

**WINDING AND TREATMENT OF COILS** The double silk-covered manganin wire is wound bifilar or Chaperon form on the silk-covered spools, one layer of wire being used whenever possible. The size of the wire is consistent with the requisite carrying capacity of the coils. They are covered with a coating of shellac dissolved in pure ethyl alcohol and aged by baking for ten to twenty hours at a temperature of  $145^{\circ}$  C. A final adjustment is not made until the coils have been in stock several months. The resistance wire terminals are brazed to copper disks, which, in turn, are soldered to the copper connecting rods. As these last are soldered into the blocks, a complete metallic circuit is formed. The sections shown on page 75 give some of the details of construction.

**SPECIAL WINDINGS** Special windings of resistance coils can be furnished. It is desirable for the customer to specifically state the purpose for which the coils are to be used.





11005

## STANDARD RESISTANCES

## REICHSANSTALT PATTERN

These resistance standards are made according to the designs and specifications of the Physikalisch-Technische Reichsanstalt. The heavy copper terminals project through the polished hard rubber top of the ventilated nickel-plated brass case. The manganin resistances are wound on large metal cylinders insulated by silk and shellac. All joints are silver brazed. The coils are adjusted to an accuracy of  $\frac{1}{100}$  % and the temperature coefficient is furnished with each coil. When the coils are used for precision measurement either in a petroleum bath or in air, the load should not exceed one watt, but if they

are intended for measuring currents only they may carry up to 10 watts in a petroleum bath.

The resistance is measured from the ends of the bent copper terminals, so that several can be connected in series or multiple. The terminals may be supplied with binding posts for potential measurements.

No.	Value in Ohms	Potential Terminal	Price
11000	.1	with	\$20.00
11001	.1	without	19.00
11002	1	with	20.00
11003	1	without	19.00
11004	10	with	20.00
11005	10	without	19.00
11006	100	with	20.00
11007	100	without	19.00
11008	1000	with	20.00
11009	1000	without	19.00
11010	10000	with	25.00
11011	10000	without	24.00

NOTE.—Resistance standards similar to the above, but of intermediate values, price on application.

**No. 11020** .001 ohm standard resistance with potential terminals mounted on the cover. The potential terminals read directly to the ends of the coil and the resistance of the bent current poles is not included in the measured resistance. Otherwise the construction is similar to the standards listed above.

Price, . . . . . \$30.00

**No. 11022** .01 ohm coil similar to No. 11020.

Price, . . . . . \$30.00

**No. 11023** .1 ohm coil similar to No. 11020.

Price, . . . . . \$30.00

**No. 11024** 1 ohm coil similar to No. 11020.

Price, . . . . . \$30.00

## PETROLEUM OIL BATHS

These petroleum baths for standard resistances consist of a nickel-plated copper tank placed between two vertical hardwood boards surmounted by vulcanite strips which are grooved to admit the free insertion of the copper bars, each of which is provided with mercury cups and with binding posts. The ends of the bent terminals of the resistance standard, as well as the bottoms of the mercury cups, should be well amalgamated before resistance measurements are undertaken. A turbine stirrer is provided with each bath.

**No. 11050** Oil bath for one standard resistance (Reichsanstalt type).

Price, . . . . . \$25.00

**No. 11051** Oil bath for four standard resistances (Reichsanstalt type). This bath is provided in addition to the stirrer with five short copper bars, having two mercury cups each, and with two long copper bars having four mercury cups each.

Price, . . . . . \$35.00

**NOTE.**—Either of the above baths can be furnished with a heating coil or a cooling coil at an additional cost.

Larger baths of special design can be furnished. Price on receipt of specifications.

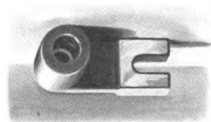
**No. 11056** Motor for driving stirrer.  $1\frac{1}{10}$  H. P. 110 volt D. C. motor.

Price, . . . . . \$16.00

**NOTE.**—On small motors of different voltages for either A. C. and D. C. current, prices will be quoted.



11090



11092

## STANDARD RESISTANCES FOR CURRENT MEASUREMENT BY POTENTIAL DIFFERENCES

These resistances, made of manganin strips, bent non-inductively, have a large radiating surface not necessitating oil immersion, and are intended for the measurement of currents by the potentiometer. Large copper current terminals and potential terminals are provided.

No.	Resistance	Capacity in Amperes	Price
11060	.1	20	\$30.00
11062	.01	100	45.00
11064	.001	300	55.00
11066	.001	600	85.00

Smaller resistances with larger current carrying capacity made to order.

## MERCURY CUP CONNECTORS

**No. 11090** These heavy copper connectors are provided with two mercury cups and two knurled clamp screws, and are used for connecting standard resistances in combination of series or multiple.

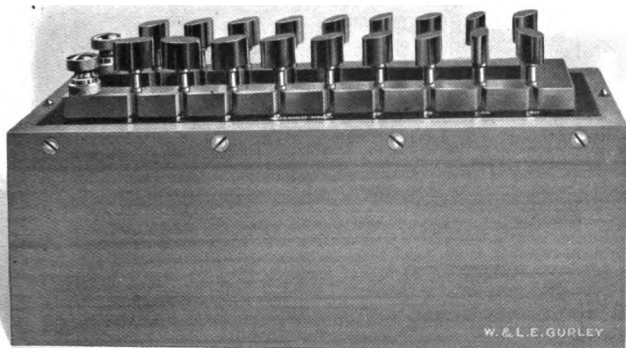
Price each, . . . . . \$ 2.00

Price per dozen, . . . . . \$20.00

**No. 11092** These copper connectors are provided on one side with a mercury cup and on the other side with a fork. They are used when it is desired to use resistance coils having amalgamated copper terminals with a bridge provided only with binding post terminals.

Price each, . . . . . \$ 1.50

Price per dozen, . . . . . \$15.00



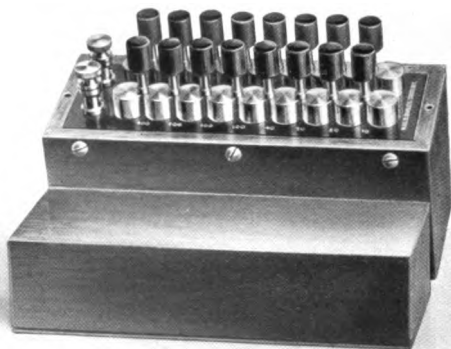
11103

## SERIES RESISTANCE BOXES

### METAL SPOOLS

In these series boxes the resistances, wound on metal spools and adjusted to an accuracy of  $\frac{1}{2}\%$ , are arranged in two rows. The sequence of resistances is 1, 2, 3, 4, although any other can be supplied on special order. Two traveling plugs are furnished.

No.	Value of Resistances in Ohms	Socket in each Block for Branch Terminal	Price
11100	1, 2, 3, 4, . . 1000 and $\infty$	with	\$75.00
11101	1, 2, 3, 4, . . 1000 and $\infty$	without	73.00
11102	1, 2, 3, 4, . . 10000 and $\infty$	with	90.00
11103	1, 2, 3, 4, . . 10000 and $\infty$	without	87.00
11104	1, 2, 3, 4, . . 4000	with	75.00
11105	1, 2, 3, 4, . . 4000	without	73.00
11106	1, 2, 3, 4, . . 400	with	60.00
11107	1, 2, 3, 4, . . 400	without	58.00
11108	.1, .2, .3, .4, . . 400	with	75.00
11109	.1, .2, .3, .4, . . 400	without	73.00
11110	.1, .2, .3, .4, . . 1000 and $\infty$	with	90.00
11111	.1, .2, .3, .4, . . 1000 and $\infty$	without	87.00
11112	.1, .2, .3, .4, . . 10000 and $\infty$	with	100.00
11113	.1, .2, .3, .4, . . 10000 and $\infty$	without	98.00



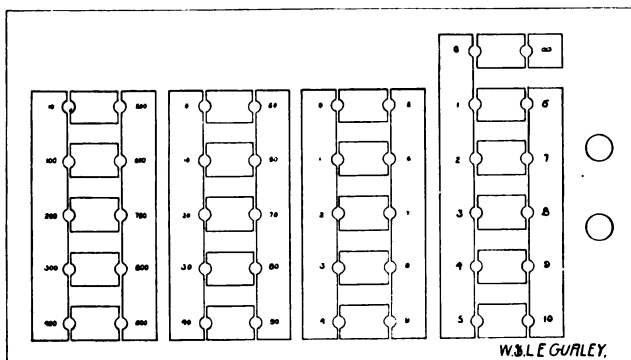
11123

## SERIES RESISTANCE BOXES

### COMPOSITION SPOOLS

These series boxes have the resistances wound on composition spools and adjusted to an accuracy of  $\frac{1}{10}\%$ . The sequence of resistances is 1, 2, 3, 4, but any other sequence can be supplied on special order. One traveling plug is furnished.

No.	Value of Resistance in Ohms	Socket in each Block for Branch Terminal	Price
11120	1, 2, 3, 4, . . 4000	with	\$30.00
11121	1, 2, 3, 4, . . 4000	without	29.00
11122	.1, .2, .3, .4, . . 400	with	30.00
11123	.1, .2, .3, .4, . . 400	without	29.00
11124	1, 2, 3, 4, . . 400	with	20.00
11125	1, 2, 3, 4, . . 400	without	19.00
11126	.1, .2, .3, .4, . . 40	with	20.00
11127	.1, .2, .3, .4, . . 40	without	19.00



11155

## DECADE RESISTANCE BOXES, PLUG FORM

### METAL SPOOLS

Decade boxes have the great advantage over series resistance boxes in the constancy of the contact resistance.

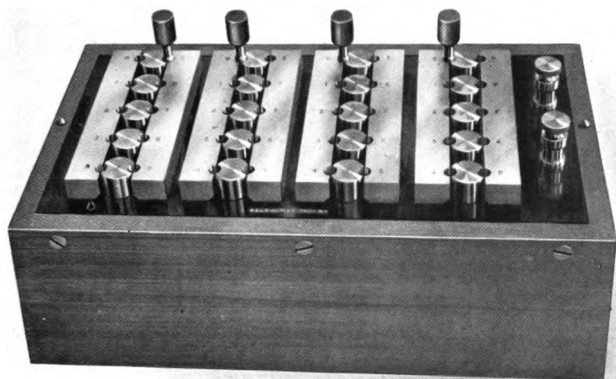
The boxes listed below have the resistances wound on metal spools and adjusted to an accuracy of  $\frac{1}{2}\frac{1}{5}\%$ , except the  $\frac{1}{10}$  ohm coils which are adjusted to  $\frac{1}{10}\%$ .

An extra plug is provided in order to avoid breaking the circuit when changing the resistance. (See page 75 for details of construction.)

No.	No. of Decades	Resistance in Decades	Price
11130	One	10 X .1, . . . . .	\$30.00
11131	"	10 X 1, . . . . .	30.00
11132	"	10 X 10, . . . . .	30.00
11133	"	10 X 100, . . . . .	30.00
11134	"	10 X 1000, . . . . .	32.00

No.	No. of Decades	Resistance in Decades	Price
11135	One	9x.1, . . . . .	\$ 28.00
11136	"	9x 1, . . . . .	28.00
11137	"	9x 10, . . . . .	28.00
11138	"	9x 100, . . . . .	28.00
11139	"	9x 1000, . . . . .	30.00
11140	Two	10x.1 + 9x 1, . . . . .	50.00
11142	"	10x 1 + 9x 10, . . . . .	50.00
11143	"	10x 10 + 9x 100, . . . . .	50.00
11144	"	10x 100 + 9x 1000, . . . . .	50.00
11145	"	9x.1 + 9x 1, . . . . .	47.00
11146	"	9x 1 + 9x 10, . . . . .	47.00
11147	"	9x 10 + 9x 100, . . . . .	47.00
11148	"	9x 100 + 9x 1000, . . . . .	47.00
11149	Three	10x.1 + 9x 1 + 9x 10, . . . . .	80.00
11150	"	10x 1 + 9x 10 + 9x 100, . . . . .	80.00
11151	"	10x 10 + 9x 100 + 9x 1000, . . . . .	80.00
11152	"	9x.1 + 9x 1 + 9x 10, . . . . .	75.00
11153	"	9x 1 + 9x 10 + 9x 100, . . . . .	75.00
11154	"	9x 10 + 9x 100 + 9x 1000, . . . . .	75.00
11155	Four	10x.1 + 9x 1 + ..... + 9x 100, . . . . .	150.00
11156	"	10x 1 + 9x 10 + ..... + 9x 1000, . . . . .	150.00
11157	"	9x.1 + 9x 1 + ..... + 9x 100, . . . . .	140.00
11158	"	9x 1 + 9x 10 + ..... + 9x 1000, . . . . .	140.00
11159	Five	10x.1 + 9x 1 + ..... + 9x 1000, . . . . .	185.00
11160	"	10x 1 + 9x 10 + ..... + 9x 10000, . . . . .	185.00
11161	"	9x.1 + 9x 1 + ..... + 9x 1000, . . . . .	175.00
11162	"	9x 1 + 9x 10 + ..... + 9x 10000, . . . . .	175.00
11163	Six	10x.1 + 9x 1 + ..... + 9x 10000, . . . . .	200.00
11164	"	9x.1 + 9x 1 + ..... + 9x 10000, . . . . .	200.00





11197

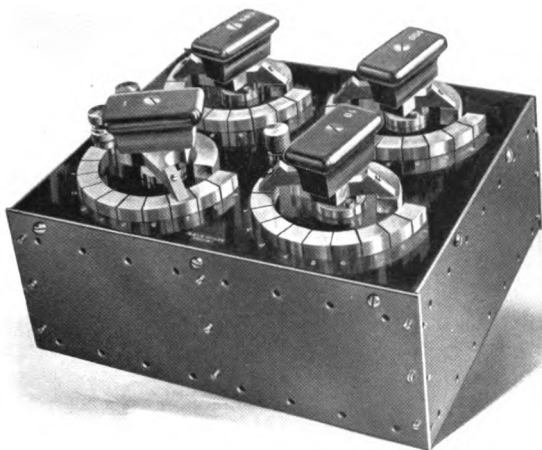
## DECADE RESISTANCE BOXES, PLUG FORM COMPOSITION SPOOLS

The decade boxes listed below have the resistances wound on composition spools and adjusted to an accuracy of  $\frac{1}{10}\%$ .

An extra plug is provided to avoid breaking the circuit when different coils are plugged in or out. (For details of construction, see page 71.)

No.	No. of Decades	Resistance in Decades	Price
11170	One	10 X .1, . . . . .	\$16.00
11171	"	10 X 1, . . . . .	15.00
11172	"	10 X 10, . . . . .	15.00
11173	"	10 X 100, . . . . .	15.00
11174	"	10 X 1000, . . . . .	16.00

No.	No. of Decades	Resistance in Decades						Price
11175	One	9 x .1,	.	.	.	.	.	\$15.00
11176	"	9 x 1,	.	.	.	.	.	14.00
11177	"	9 x 10,	.	.	.	.	.	14.00
11178	"	9 x 100,	.	.	.	.	.	14.00
11179	"	9 x 1000,	.	.	.	.	.	16.00
11180	Two	10 x .1 + 9 x 1,	.	.	.	.	.	23.00
11181	"	10 x 1 + 9 x 10,	.	.	.	.	.	20.00
11182	"	10 x 10 + 9 x 100,	.	.	.	.	.	20.00
11183	"	10 x 100 + 9 x 1000,	.	.	.	.	.	22.00
11184	"	9 x .1 + 9 x 1,	.	.	.	.	.	22.00
11185	"	9 x 1 + 9 x 10,	.	.	.	.	.	19.00
11186	"	9 x 10 + 9 x 100,	.	.	.	.	.	19.00
11187	"	9 x 100 + 9 x 1000,	.	.	.	.	.	20.00
11188	Three	10 x .1 + 9 x 1 + 9 x 10,	.	.	.	.	.	35.00
11189	"	10 x 1 + 9 x 10 + 9 x 100,	.	.	.	.	.	35.00
11190	"	10 x 10 + 9 x 100 + 9 x 1000,	.	.	.	.	.	35.00
11191	"	9 x .1 + 9 x 1 + 9 x 10,	.	.	.	.	.	33.00
11192	"	9 x 1 + 9 x 10 + 9 x 100,	.	.	.	.	.	33.00
11193	"	9 x 10 + 9 x 100 + 9 x 1000,	.	.	.	.	.	33.00
11194	Four	10 x .1 + 9 x 1 ..... + 9 x 100,	.	.	.	.	.	47.00
11195	"	10 x 1 + 9 x 10 ..... + 9 x 1000,	.	.	.	.	.	47.00
11196	"	9 x .1 + 9 x 1 ..... + 9 x 100,	.	.	.	.	.	45.00
11197	"	9 x 1 + 9 x 10 ..... + 9 x 1000,	.	.	.	.	.	45.00
11198	Five	10 x .1 + 9 x 1 ..... + 9 x 1000,	.	.	.	.	.	57.00
11199	"	10 x 1 + 9 x 10 ..... + 9 x 10000,	.	.	.	.	.	62.00
11200	"	9 x .1 + 9 x 1 ..... + 9 x 1000,	.	.	.	.	.	55.00
11201	"	9 x 1 + 9 x 10 ..... + 9 x 10000,	.	.	.	.	.	60.00
11202	Six	10 x .1 + 9 x 1 ..... + 9 x 10000,	.	.	.	.	.	72.00
11203	"	9 x .1 + 9 x 1 ..... + 9 x 10000,	.	.	.	.	.	70.00



11237, in metal case

## DECADE RESISTANCE BOXES WITH SLIDING CONTACTS METAL SPOOLS

A sliding contact resistance box is more rapidly and conveniently manipulated than a plug box. (See page 73 for the mechanical construction of these sliding contact boxes.)

The above illustration shows a four decade sliding contact resistance box mounted in a perforated metal case. Unless specifically ordered in a metal case, the resistances are mounted in polished mahogany cases as shown on page 89.

The boxes listed below have the resistances wound on metal spools and adjusted to an accuracy of  $\frac{1}{2}\%$ . Heavy terminal binding posts are provided.

**NOTE.**—If each decade shall have ten values, add 10% to the list prices on following page.

If the decades are to be covered with glass, add 10% to the list prices on following page.

# DECADE RESISTANCE BOXES WITH SLIDING CONTACTS

## METAL SPOOLS

No.	No. of Decades	Resistance in Decades	Price
11210	One	10 x .1, . . . . .	\$35.00
11211	"	10 x 1, . . . . .	35.00
11212	"	10 x 10, . . . . .	35.00
11213	"	10 x 100, . . . . .	35.00
11214	"	10 x 1000, . . . . .	35.00
11215	"	9 x .1, . . . . .	33.00
11216	"	9 x 1, . . . . .	33.00
11217	"	9 x 10, . . . . .	33.00
11218	"	9 x 100, . . . . .	33.00
11219	"	9 x 1000, . . . . .	33.00
11220	Two	10 x .1 + 9 x 1, . . . . .	52.00
11221	"	10 x 1 + 9 x 10, . . . . .	52.00
11222	"	10 x 10 + 9 x 100, . . . . .	52.00
11223	"	10 x 100 + 9 x 1000, . . . . .	55.00
11224	"	9 x .1 + 9 x 1, . . . . .	50.00
11225	"	9 x 1 + 9 x 10, . . . . .	50.00
11226	"	9 x 10 + 9 x 100, . . . . .	50.00
11227	"	9 x 100 + 9 x 1000, . . . . .	52.00
11228	Three	10 x .1 + 9 x 1 + 9 x 10, . . . . .	92.00
11229	"	10 x 1 + 9 x 10 + 9 x 100, . . . . .	92.00
11230	"	10 x 10 + 9 x 100 + 9 x 1000, . . . . .	92.00
11231	"	9 x .1 + 9 x 1 + 9 x 10, . . . . .	88.00
11232	"	9 x 1 + 9 x 10 + 9 x 100, . . . . .	88.00
11233	"	9 x 10 + 9 x 100 + 9 x 1000, . . . . .	88.00
11234	Four	10 x .1 + 9 x 1 + ..... + 9 x 100, . . . . .	120.00
11235	"	10 x 1 + 9 x 10 + ..... + 9 x 1000, . . . . .	120.00
11236	"	9 x .1 + 9 x 1 + ..... + 9 x 100, . . . . .	116.00
11237	"	9 x 1 + 9 x 10 + ..... + 9 x 1000, . . . . .	116.00
11239	Five	10 x .1 + 9 x 1 + ..... + 9 x 1000, . . . . .	140.00
11240	"	10 x 1 + 9 x 10 + ..... + 9 x 10000, . . . . .	145.00
11241	"	9 x .1 + 9 x 1 + ..... + 9 x 1000, . . . . .	136.00
11242	"	9 x 1 + 9 x 10 + ..... + 9 x 10000, . . . . .	141.00
11243	Six	10 x .1 + 9 x 1 + ..... + 9 x 10000, . . . . .	165.00
11244	"	9 x .1 + 9 x 1 + ..... + 9 x 10000, . . . . .	160.00



# DECADE RESISTANCE BOXES WITH SLIDING CONTACTS

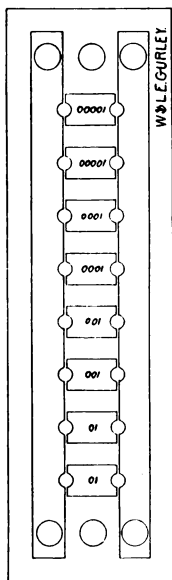
## COMPOSITION SPOOLS

The boxes listed below have the resistances wound on composition spools and adjusted to an accuracy of  $\frac{1}{10}\%$ .

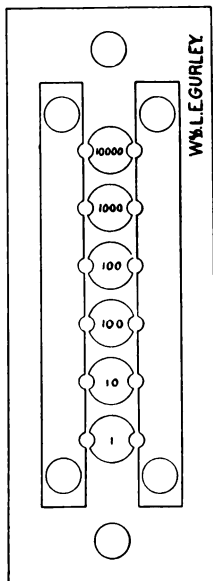
The handles are round and no spring clips are provided, otherwise the construction is similar to that described on page 73.

No.	No. of Decades	Resistance in Decades	Price
11250	One	10 x .1, . . . . .	\$ 22.00
11251	"	10 x 1, . . . . .	20.00
11252	"	10 x 10, . . . . .	21.00
11253	"	10 x 100, . . . . .	21.00
11254	"	10 x 1000, . . . . .	22.00
11255	"	9 x .1, . . . . .	21.00
11256	"	9 x 1, . . . . .	19.00
11257	"	9 x 10, . . . . .	20.00
11258	"	9 x 100, . . . . .	20.00
11259	"	9 x 1000, . . . . .	21.00
11260	Two	10 x .1 + 9 x 1, . . . . .	42.00
11261	"	10 x 1 + 9 x 10, . . . . .	40.00
11262	"	10 x 10 + 9 x 100, . . . . .	40.00
11263	"	10 x 100 + 9 x 1000, . . . . .	42.00
11264	"	9 x .1 + 9 x 1, . . . . .	40.00
11265	"	9 x 1 + 9 x 10, . . . . .	38.00
11266	"	9 x 10 + 9 x 100, . . . . .	38.00
11267	"	9 x 100 + 9 x 1000, . . . . .	40.00
11268	Three	10 x .1 + 9 x 1 + 9 x 10, . . . . .	62.00
11269	"	10 x 1 + 9 x 10 + 9 x 100, . . . . .	61.00
11270	"	10 x 10 + 9 x 100 + 9 x 1000, . . . . .	62.00
11271	"	9 x .1 + 9 x 1 + 9 x 10, . . . . .	60.00
11272	"	9 x 1 + 9 x 10 + 9 x 100, . . . . .	59.00
11273	"	9 x 10 + 9 x 100 + 9 x 1000, . . . . .	60.00
11274	Four	10 x .1 + 9 x 1 + ..... + 9 x 100, . . . . .	85.00
11275	"	10 x 1 + 9 x 10 + ..... + 9 x 1000, . . . . .	85.00
11276	"	9 x .1 + 9 x 1 + ..... + 9 x 100, . . . . .	83.00
11277	"	9 x 1 + 9 x 10 + ..... + 9 x 1000, . . . . .	83.00
11279	Five	10 x .1 + 9 x 1 + ..... + 9 x 1000, . . . . .	100.00
11280	"	10 x 1 + 9 x 10 + ..... + 9 x 10000, . . . . .	105.00
11281	"	9 x .1 + 9 x 1 + ..... + 9 x 1000, . . . . .	98.00
11282	"	9 x 1 + 9 x 10 + ..... + 9 x 10000, . . . . .	103.00
11283	Six	10 x .1 + 9 x 1 + ..... + 9 x 10000, . . . . .	112.00
11284	"	9 x .1 + 9 x 1 + ..... + 9 x 10000, . . . . .	110.00

NOTE.—If each decade shall have ten values, add 10% to the above prices.  
If the decades are to be glass covered, add 10% to the above prices.



11301



11307

## RATIO RESISTANCES

(After SCHÖNE)

## METAL SPOOLS

This method of arranging ratio resistances was devised by O. Schöne (Zeitschrift der Instrumentenkunde, Vol. XVIII, p. 133), and has all the advantages of a decade arrangement, but more flexibility, as the combination of series and multiple can be made. For precise measurements the interchange of the coils from one side to the other is easily made. The following boxes have the resistances wound on metal spools and adjusted to an accuracy of  $\frac{1}{50}\%$ .

No.	Resistances	No. of Coils	Price
11300	1, 1, 10, 10, 100, 100, 1000, 1000	8	\$60.00
11301	10, 10, 100, 100, 1000, 1000, 10000, 10000	8	66.00
11302	1, 1, 10, 10, 100, 100, 1000, 1000, 10000, 10000	10	80.00

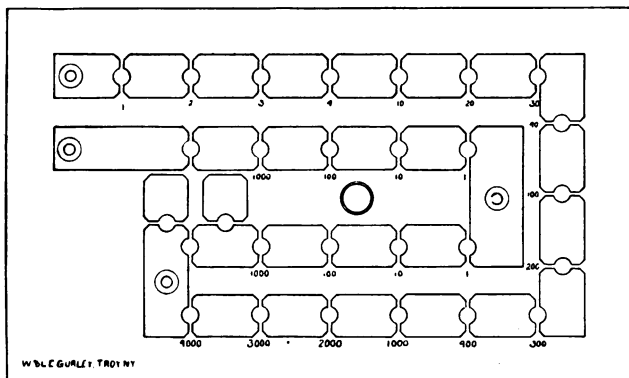
## RATIO RESISTANCES

## COMPOSITION SPOOLS

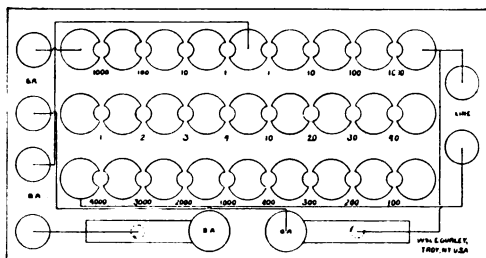
The following ratio sets are arranged in a similar manner to the above. The resistances are wound on composition spools and adjusted to an accuracy of  $\frac{1}{25}\%$ .

No.	Resistances	No. of Coils	Price
11305	1, 1, 10, 10, 100, 100	6	\$30.00
11306	10, 10, 100, 100, 1000, 1000	6	30.00
11307	1, 10, 100, 100, 1000, 10000	6	30.00
11308	1, 1, 10, 10, 100, 100, 1000, 1000	8	33.00
11309	1, 1, 10, 10, 100, 100, 1000, 1000, 10000, 10000	10	40.00





11312



11318

## BOX BRIDGES

## BRIDGES WITH SERIES RHEOSTAT AND PLUG CONNECTION

**No. 11312** This high-grade resistance box and Wheatstone bridge has four pairs of ratio resistances (1, 10, 100, 1,000 ohms) and fifteen rheostat coils from 1 to 4,000 ohms. The ratio coils are reversible. The resistances are all wound on metal spools. The rheostat coils are correct to  $\frac{1}{25}\%$ , and the ratio coils  $\frac{1}{50}\%$  at 20° centigrade.

The box is not supplied with keys. Each block is provided with a central reamed socket for traveling plugs.

Price, . . . . . \$115.00

**No. 11315** This high-grade Wheatstone bridge is similar to No. 11312, but is provided with galvanometer and battery keys.

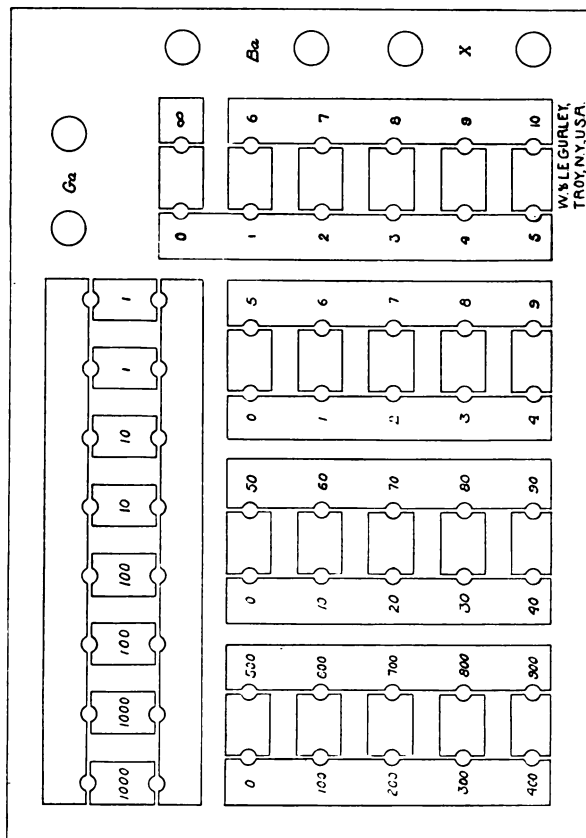
Price, . . . . . \$125.00

## WHEATSTONE BRIDGE FOR STUDENTS

**No. 11318** This Wheatstone bridge has four pairs of ratio resistances of 1, 10, 100, and 1,000 ohms. The rheostat coils are from 1 to 4,000 ohms. The resistances are wound on our composition spools, and are correct to  $\frac{1}{10}\%$  at 20° centigrade. The connections are traced on the polished hard rubber top.

Battery and galvanometer keys are provided.

Price, . . . . . \$40.00



11326

## BRIDGES WITH DECADE RHEOSTAT AND PLUG CONNECTION

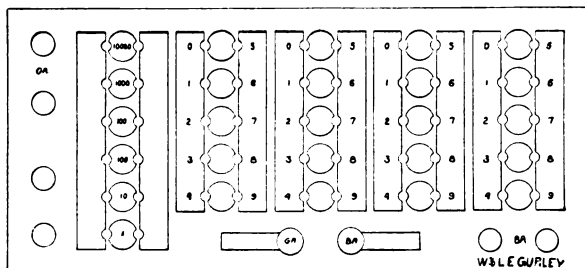
### METAL SPOOLS

The following decade bridges have all the coils wound on metal spools and are of our high grade type (see page 75). The ratio resistances are adjusted to an accuracy of  $\frac{1}{50}\%$  and the rheostat coils to an accuracy of  $\frac{1}{25}\%$ , with the exception of the  $\frac{1}{10}$  ohm coils, which are correct to  $\frac{1}{10}\%$ .

The lowest value decade has ten values, the others nine. The ratio resistances have the values 1, 10, 100, 1,000 ohms in pairs.

No.	No. Decades in Rheostat	Value of Decades	Rheostat same as No.	Keys on Box	Price
11324	4	.1, 1, 10, 100	11234	without	\$180.00
11325	4	.1, 1, 10, 100	11234	with	190.00
11326	4	1, 10, 100, 1000	11235	without	180.00
11327	4	1, 10, 100, 1000	11235	with	190.00
11328	5	.1, 1, 10, 100, 1000	11239	without	200.00
11329	5	.1, 1, 10, 100, 1000	11240	with	210.00
11330	5	1, 10, 100, 1000, 10000	11239	without	205.00
11331	5	1, 10, 100, 1000, 10000	11240	with	215.00
11332	6	.1, 1, 10, 100, 1000, 10000	11243	without	225.00
11333	6	.1, 1, 10, 100, 1000, 10000	11243	with	235.00

NOTE.—When ratio resistances having ten values, namely, 1, 1, 10, 10, 100, 100, 1,000, 1,000, 10,000, 10,000, are desired on the above boxes, add \$20.00 to the list prices.



11353

## BRIDGES WITH DECADE RHEOSTAT AND PLUG CONNECTION

### COMPOSITION SPOOLS

The following decade bridges have the resistances wound on composition spools. The ratio coils are adjusted to an accuracy of  $\frac{1}{10}\%$  and the rheostat coils to  $\frac{1}{25}\%$ . All the decades have nine values.

The ratio resistances have the following values : 1, 10, 100, 100, 1,000, 10,000 ohms. They are arranged similar to No. 11307 (page 91).

No.	No. Decades in Rheostat	Value of Decades	Rheostat same as No.	Keys on Box	Price
11350	4	.1, 1, 10, 100	11307	without	\$ 85.00
11351	4	.1, 1, 10, 100	11307	with	95.00
11352	4	1, 10, 100, 1000	11307	without	85.00
11353	4	1, 10, 100, 1000	11307	with	95.00
11354	5	.1, 1, 10, 100, 1000	11307	without	95.00
11355	5	.1, 1, 10, 100, 1000	11307	with	105.00
11356	5	1, 10, 100, 1000, 10000	11307	without	100.00
11357	5	1, 10, 100, 1000, 10000	11307	with	110.00
11358	6	.1, 1, 10, 100, 1000, 10000	11307	without	120.00
11359	6	.1, 1, 10, 100, 1000, 10000	11307	with	130.00

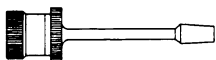
## ANTHONY FORM OF WHEATSTONE BRIDGE

## METAL SPOOLS

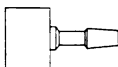
**No. 11370** This Anthony Form of Wheatstone bridge has five pairs of ratio resistances of 1, 10, 100, 1,000, and 10,000 ohms. The rheostat coils, fifty in number, are arranged in five decades. These may be joined in series or in parallel. The bridge is one of the most flexible forms that can be used, and allows a thorough checking of the coils among themselves. The ratio resistances are adjusted to an accuracy of  $\frac{1}{50}\%$  and the rheostat resistance to  $\frac{1}{25}\%$ .

The box is provided with battery and galvanometer keys.

Price, . . . . . \$350.00



11402



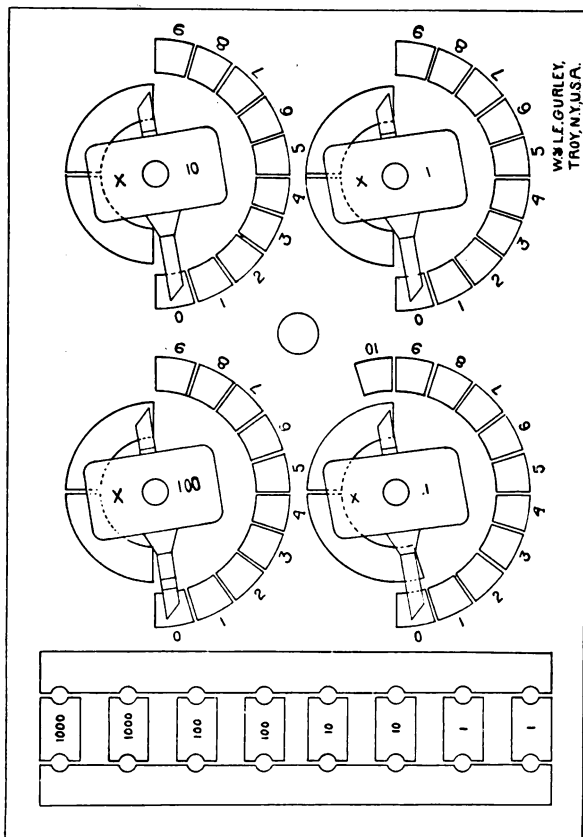
11401



11400

## PLUGS FOR RESISTANCE BOXES

No.		Each	Per Doz.
11400	Flat pattern plug, . . . . .	\$0.35	\$ 3.50
11401	Round pattern plug, . . . . .	.20	2.00
11402	Traveling plug, . . . . .	1.00	10.00



747445

## WHEATSTONE BRIDGES AND RESISTANCE BOXES, SLIDING CONTACTS

### METAL SPOOLS

The sliding contacts for each decade are made in two semi-circles instead of a complete circle, on account of the convenience of manipulation. The ratio resistances are plug connected and of the decade type.

The resistances are wound on metal spools. The ratio coils are adjusted to an accuracy of  $\frac{1}{50}\%$  and the rheostat coils to  $\frac{1}{25}\%$ . Each rheostat decade has nine values and is provided with an elongated handle with spring catch which engages as the contact brushes pass over the center of the blocks. The handle and brush frame can be readily removed for cleaning the brushes and contacts. For details of construction, see page 73.

No.	No. Decades in Rheostat	Value of Decades	Rheostat same as No.	Keys on Box	Price
11410	4	.1, 1, 10, 100	11300	without	\$175.00
11411	4	.1, 1, 10, 100	11300	with	185.00
11412	4	1, 10, 100, 1000	11300	without	175.00
11413	4	1, 10, 100, 1000	11300	with	185.00
11414	5	.1, 1, 10, 100, 1000	11300	without	190.00
11415	5	.1, 1, 10, 100, 1000	11300	with	200.00
11416	5	1, 10, 100, 1000, 10000	11301	without	200.00
11417	5	1, 10, 100, 1000, 10000	11301	with	210.00
11418	6	.1, 1, 10, 100, 1000, 10000	11301	without	220.00
11419	6	.1, 1, 10, 100, 1000, 10000	11301	with	230.00

NOTE.—If each decade shall have ten values, add 10% to the above prices. If the decades are to be covered with glass, add 10% to the above prices.



## WHEATSTONE BRIDGES AND RESISTANCE BOXES, SLIDING CONTACTS

### COMPOSITION SPOOLS

The following Wheatstone bridges with sliding contacts are furnished with our composition spools, those of the ratio coils being adjusted to an accuracy of  $\frac{1}{25}\%$  and those of the rheostat to an accuracy of  $\frac{1}{10}\%$ . The handles are circular in form and are not provided with a spring clip.

All decades have nine values.

No.	No. Decades in Rheostat	Value of Decades	Rheostat same as No.	Keys on Box	Price
11425	4	.1, 1, 10, 100	11307	without	\$100.00
11426	4	.1, 1, 10, 100	11307	with	106.00
11427	4	1, 10, 100, 1000	11307	without	100.00
11428	4	1, 10, 100, 1000	11307	with	106.00
11429	5	.1, 1, 10, 100, 1000	11307	without	116.00
11430	5	.1, 1, 10, 100, 1000	11307	with	122.00
11431	5	1, 10, 100, 1000, 10000	11307	without	116.00
11432	5	1, 10, 100, 1000, 10000	11307	with	122.00
11433	6	.1, 1, 10, 100, 1000, 10000	11309	without	134.00
11434	6	.1, 1, 10, 100, 1000, 10000	11309	with	140.00

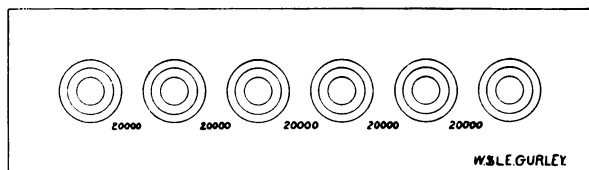
NOTE.—If each decade shall have ten values, add 10% to the above prices.  
If the decades are to be covered with glass, add 10% to the above prices.

## STANDARD HIGH RESISTANCES

The resistances listed under Nos. 11450 to 11484 are all wound of manganin wire on metal spoils.

**No. 11420 Megohm Box.** The ten units of 100,000 ohms each may be connected in any combination of series or parallel, giving the resistance of 10,000 to 1,000,000 ohms. Each unit of 100,000 ohms is made up of four 25,000 ohm coils. The terminals of each unit are brought through undercut insulation pillars to binding posts, the connections being made with contact strips instead of with plugs.

Price, . . . . . \$190.00

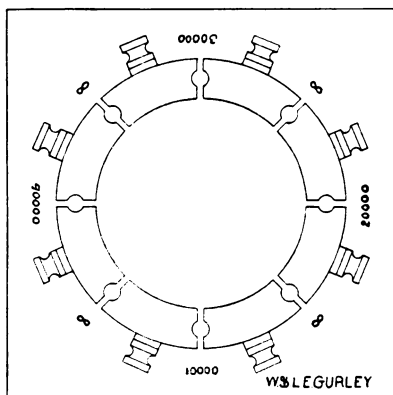


11454

**No. 11454 Resistance one Megohm.** This box contains five units of 200,000 ohms, each unit being composed of four 50,000 ohm coils. The terminals of each unit are brought through the rubber top to binding posts mounted on undercut insulation pillars. Copper links are provided for connecting the six terminals. The coils are mounted in a mahogany box.

Price, . . . . . \$150.00

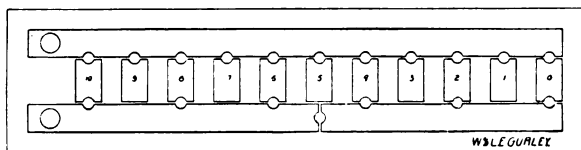
**No. 11458 100,000 ohms Resistance Box.** The four coils, 10,000, 20,000, 30,000, 40,000 ohms, are connected to segments of a circle mounted on undercut insulation pillars on



11458

the hard rubber top. Each segment is provided with a binding post, and an infinity plug separates it from its adjacent one.

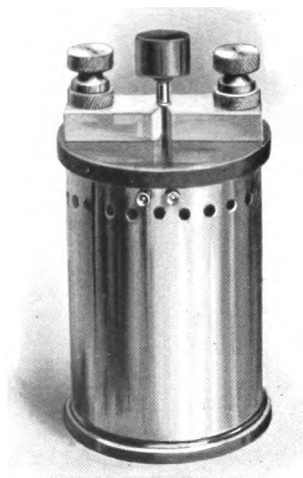
Price, . . . . . \$50.00



11462

**No. 11462** 100,000 ohms resistance box. This contains ten coils of 10,000 ohms each. They may be arranged in any combination of series or parallel to obtain resistances from 1,000 to 100,000 ohms. All blocks are mounted on undercut hard rubber supports.

Price, . . . . . \$100.00



11466

**No. 11464** Resistance 100,000 ohms. The coil is mounted in a perforated nickel-plated brass case, with polished hard rubber top. Coil adjusted to  $1\frac{1}{10}\%$ .

Price, . . . . . \$30.00

**No. 11466** Resistance 50,000 ohms. Mounted in a manner similar to No. 11464.

Price, . . . . . \$24.00

**No. 11468** Resistance 25,000 ohms. Mounted in a manner similar to No. 11464.

Price, . . . . . \$20.00

**No. 11470** Resistance 10,000 ohms. Mounted in a manner similar to No. 11464.

Price, . . . . . \$18.00

**No. 11474** Resistance 500,000 ohms. This resistance is mounted in a mahogany case with hard rubber top. Two terminals on insulation pillars are provided. The coils are wound in five units of 100,000 ohms each.

Price, . . . . . \$125.00

**No. 11478** Resistance 250,000 ohms. Mounted in a manner similar to No. 11474, but containing five units of 50,000 ohms each.

Price, . . . . . \$75.00

**No. 11480** Resistance 100,000 ohms. Mounted in a manner similar to No. 11474, but in four units of 25,000 ohms each.

Price, . . . . . \$35.00

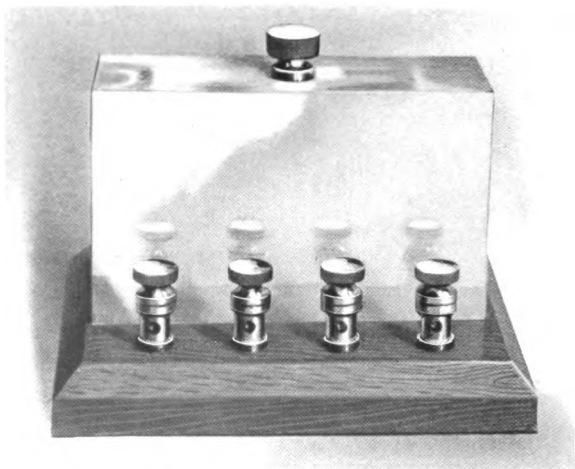
**No. 11484** Resistance 50,000 ohms. Mounted in a manner similar to No. 11474.

Price, . . . . . \$25.00

## UNMOUNTED RESISTANCE COILS

These manganin resistances are wound on composition spools and provided with copper terminals.

No.	Value of Coils in Ohms	Accuracy	Price each
11490	1, 2, 3, 4, or 5,	$\frac{1}{5}\%$	\$0.50
11491	1, 2, 3, 4, or 5,	$\frac{1}{25}\%$	1.00
11492	10, 20, 30, 40, or 50,	$\frac{1}{5}\%$	.60
11493	10, 20, 30, 40, or 50,	$\frac{1}{25}\%$	1.20
11494	100, 200, 300, 400, or 500,	$\frac{1}{5}\%$	.75
11495	100, 200, 300, 400, or 500,	$\frac{1}{25}\%$	1.50
11496	1000, 2000, 3000, or 4000,	$\frac{1}{5}\%$	1.00
11497	1000, 2000, 3000, or 4000,	$\frac{1}{25}\%$	2.00
11498	5000 or 10000,	$\frac{1}{5}\%$	3.00
11499	5000 or 10000,	$\frac{1}{25}\%$	4.00



11510

## STUDENTS' EXPERIMENTAL RESISTANCE SET

(After PROF. W. L. ROBB)

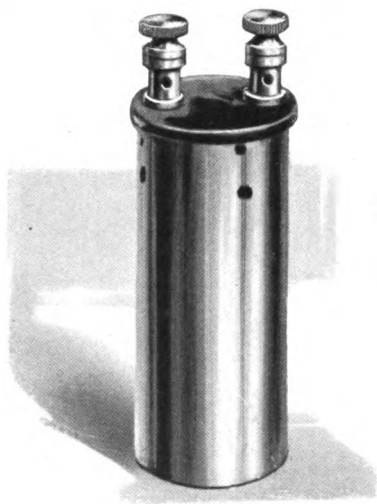
**No. 11510** Four coils are mounted on a polished mahogany base with two binding post terminals for each coil. The coils are covered with a removable nickel-plated metal case.

This piece of apparatus is instructive in showing the method of winding coils, and the resistance may be measured in single or in any series or multiple combination. The coils have the following values: 10, 20, 30, 40 ohms, made of manganin wire and adjusted to an accuracy of  $\frac{1}{2}\%$ .

Price, . . . . . \$14.00

**No. 11512** Four coils similar to No. 11510, but with the four coils unadjusted yet approximately of the values noted in No. 11510. Having the resistance no fixed unit, it is even more instructive for the student than where they have a known definite multiple value of one.

Price, . . . . . \$11.00



11525

## STUDENTS' SINGLE RESISTANCE COILS

These single resistance coils are wound on metal spools and mounted in a ventilated nickel-plated brass case with polished hard rubber top. The coils are adjusted to an accuracy of  $\frac{1}{50}\%$  and may be used as secondary standards.

No.	Value in Ohms	Price	No.	Value in Ohms	Price
11515	.1	\$12.00	11528	40	\$10.00
11516	.2	12.00	11529	50	10.00
11517	.3	12.00	11531	100	10.00
11518	.4	12.00	11532	200	10.00
11519	.5	10.00	11533	300	10.00
11520	1	10.00	11534	400	10.00
11521	2	10.00	11535	500	10.00

No.	Value in Ohms	Price	No.	Value in Ohms	Price
11522	3	\$10.00	11536	1000	\$15.00
11523	4	10.00	11537	2000	15.00
11524	5	10.00	11538	3000	15.00
11525	10	10.00	11539	4000	15.00
11526	20	10.00	11540	5000	15.00
11527	30	10.00			

These are made of manganin wire wound on composition spools and mounted on a hardwood base with copper terminals. They are adjusted to an accuracy of  $\frac{1}{10}\%$ .

No.	Value in Ohms	Price	No.	Value in Ohms	Price
11550	.1	\$5.00	11563	40	\$5.00
11551	.2	5.00	11564	50	5.00
11552	.3	5.00	11566	100	5.00
11553	.4	5.00	11567	200	6.00
11554	.5	5.00	11568	300	6.00
11555	1	5.00	11569	400	6.00
11556	2	5.00	11570	500	6.00
11557	3	5.00	11571	1000	6.00
11558	4	5.00	11572	2000	8.00
11559	5	5.00	11573	3000	8.00
11560	10	5.00	11574	4000	8.00
11561	20	5.00	11575	5000	8.00
11562	30	5.00	11576	10000	8.00





11600

### RING RHEOSTAT FOR EXPERIMENTAL PURPOSES

**No. 11600** The resistance wire is wound on a built-up wooden ring with the individual coils thoroughly insulated from each other and from the wooden ring and base. The outside diameter of the ring is 17 cm. and the resistance is about 20 ohms. This rheostat will be found very convenient in a laboratory where small variations of resistance are desired.

Price, . . . . . \$7.00

**NOTE.**—Laboratory rheostats of other values and other forms will be quoted on when desired.

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